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TECHNICAL REPORT NO. LWL-CR-08S71

EMERGENCY REPAIR SHELTER FOR THE CH47 HELICOPTER

Final Report

Contract No. DAAD05-72-C-0183

February 1973

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In Collaboration with

Norman P. Leibel  
U. S. Army Land Warfare Laboratory

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## ABSTRACT

The purpose of this task was to design, develop and fabricate two sets of emergency repair shelters to fit the CH47 helicopter.

Each set was to consist of two individually separate units. The one is essentially a curtain like flap to enclose the rear cargo ramp opening. The other covers either the port or starboard engine and is comprised of a fiberglass framework and tent like shelter. In general, the shelters were required to be lightweight and easily erected and disassembled. They were to be constructed to withstand wind velocities up to 40 miles per hour.

This report provides a discussion of the design considerations, a comprehensive description of the final shelter assemblies and instructions for their use.



# FOREWORD

This Report was prepared for the Land Warfare Laboratory, Aberdeen Proving Ground, Maryland, by the Franklin Institute Research Laboratories of Philadelphia. This report represents the results of the task assignment conducted under Contract DAAD05-72-C-0183 during the period from February 1972 through November 1972. This effort was conducted to provide two sets of prototype shelters for concept evaluation.

We wish to acknowledge the cooperation of the personnel and management of the Vertol Division of Boeing Company, Eddystone, Pennsylvania, for their assistance in the completion of this project.



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## 1. INTRODUCTION

Under adverse arctic conditions, it is nearly impossible to work on machines and equipment without some protection from the wind and cold. In the course of the initial arctic testing of the CH-47 helicopter it became quite evident that a need existed for some form of temporary shelter when emergency repairs are required away from direct support areas with fixed installation maintenance facilities.

An Approved Material Need was written (USACDC Action Control Number 17846), defining the need for such a shelter for emergency field repairs. This M.N., however, described a very large shelter intended to fully enclose half of the aircraft from the ground up over the rotor hub. Information subsequently fed back from the field indicates that a need also exists for smaller shelters for a few individual maintenance locations. The most common emergency repairs encountered are in the areas of the main turbine engines and the generator, hydraulic, A.P.U. section in the ramp area. Problems encountered here are generally of a quick fix nature if some shelter is readily available. These shelters may therefore, be supplementary to the more extensive inflated shelter, and may conceivably suffice for 75% of the emergency conditions encountered in the field.

The development of these engineering prototypes was initiated by the U.S. Army Land Warfare Laboratory primarily to evaluate the concept and to determine if any other similar individual shelters should be developed.



## 2. DESIGN CRITERIA

### 2.1 BACKGROUND

With the advent of the helicopter into the military inventory, there had never been a project undertaken to develop a lightweight, portable type repair shelter for use where fixed or semi-permanent facilities were not adequate or available. The aviation maintenance shelters described in paragraph 1639 of the Combat Development Objectives Guide, though sufficient for their intended purposes, are not applicable in the situations where, in the interest of safety to the aircrew, cargo or aircraft, the helicopter must land in remote areas in order to make minor repairs to a malfunctioning component or subsystem.

In April 1965, the U.S. Army Arctic Test Center developed proposed requirements for a CH-47 maintenance shelter that was deemed necessary as a result of arctic testing of the CH-47 helicopter (USATECOM Project No. 4-3-0200-06-R). Subsequently development began on a shelter to protect mechanics while performing maintenance in the arctic under emergency conditions. This shelter was intended to enclose major portions of the aircraft, i.e., engines, rear rotor head and rear pylon, or by repositioning, the shelter would enclose the forward rotor head and pylon. An initial prototype shelter was fabricated and tested (USATECOM Project No. 7-7-0816-01) some deficiencies were noted and further development effort was recommended.

While this work continued, it was decided that a short term small development effort should be made to evaluate the concept of smaller individual shelters for the more common field servicing and maintenance problems.

As a part of a supporting services contract, USALWL initiated a task No. 08-S-71 on February 22, 1972 for the design, development and fabrication of two sets of emergency repair shelters for the CH-47 helicopter. In



keeping with the primary mission of USALWL, a quick response was a major task objective.

Each set of shelters consists of two distinct types. One shelter is essentially a curtain like flap which encloses the rear cargo ramp opening to facilitate repairs to the auxiliary power plant located in the roof of the cabin. The other shelter is to be used to facilitate minor repairs and servicing of either the port or starboard turbine engines. The shelters are required to conform closely to the fuselage contours to effectively seal out the cold arctic wind. Access to the engine shelter is required from toeholds built into the helicopter and the existing lower work platform is totally enclosed.

A heater duct connection is provided on the engine shelter which is compatible with the Herman Nelson heater.

In general the shelters were required to be lightweight and easily erected and disassembled, and strong enough to withstand a 40 mile an hour wind.

## 2.2 OPERATIONAL CHARACTERISTICS

The design intent was to provide for ease of erection without modification to the aircraft and without the need for special tools or the removal of protective gloves. Lines were to be attached to existing tie points. The shelter structure was to be supported only on the sprung portion of the aircraft, so that any movement of the aircraft, relative to the ground, due to wind, etc., would not affect the tension in the guy lines or fabric.

## 2.3 WEIGHT

The desired weight of the shelter, including the supporting framework ropes, guylines and fasteners was not to exceed fifty pounds.



## 2.4 MATERIALS

The shelter material was specified to be Boiled Off Heat Set neoprene coated nylon twill, 80x80 count to meet MIL-C-577F. Total coated maximum weight 3.75 ounces per square yard. This is a flexible, lightweight, windbreaking, water repellent fabric which is impervious to hydraulic fluids, gasoline and oil.

The framework or supporting structure was to be fabricated from fiberglass reinforced plastic. In general, the hardware was to present the minimum amount of bare metal surfaces.

## 2.5 REACTION TIME

Unpacking, assembly and erection of the shelter was to be completed in not more than twenty minutes by two men. Striking the shelter repacking was to require no more than fifteen minutes for two men.

## 2.6 SHELTER ENVELOPE

### 2.6.1 Cargo Ramp Enclosure

Servicing and maintenance of the Auxiliary-Power Unit (A.P.U.) in the cabin roof is usually accomplished by partially lowering the cargo ramp to a horizontal or slightly raised position with the cargo door retracted. The cargo ramp enclosure is designed to cover the entire opening from side to side at the ramp hinge, across the back of the aircraft with the ramp opened. Since no discrete angular position of the ramp was specified, the enclosure is designed to accommodate a variation of approximately 10° from slightly below the horizontal. This was accomplished by providing excess fabric and elastic tie lines under the ramp.

Primary support for the enclosure is from the ridge line. This arrangement was selected as the simplest form with the least tie points. Trial and examination on the scale model indicated that a line secured at each jack pad near the rear landing gear and routed up over the cargo



ramp opening on the outside of the fuselage below the pylon base, would be suitable and could support a substantial load because of the shape of the fuselage itself (see Figure 2.1). With this support for the curtain established, it was then necessary to design and locate tie points to make the enclosure conform to the contour of the aircraft. The belt line ties were provided to pull the fabric into the concave contour near the fuselage midline. A considerable amount of time was required in fitting and tailoring the end panels at the wheel well area. Tie points were established to the inside bulkheads and stringers and to the cargo tie down rings.

A specific folding and packing procedure was worked out to reduce the amount of fabric area exposed to the wind while the enclosure is being raised. Keeping the fabric partially folded and tied greatly reduces the flapping and billowing of the enclosure before the ridge line is secured.

## 2.6.2 Engine Shelter

Several frame and envelop configurations were sketched, modeled and evaluated. The principal factors considered in the evaluation were:

- enclosed working volume
- minimum rigid frame members
- fabric area
- entry and exit
- pitching and striking procedures
- expense and complication of hardware
- manufacturing methods and processes
- critical materials
- restrictive specifications

The enclosed work volume around the engine was based on measurements taken on the aircraft with the work platform and the engine nacelle opened and accessible for servicing from above and below. The shelter encloses the lower work platform and the entire engine with the upper



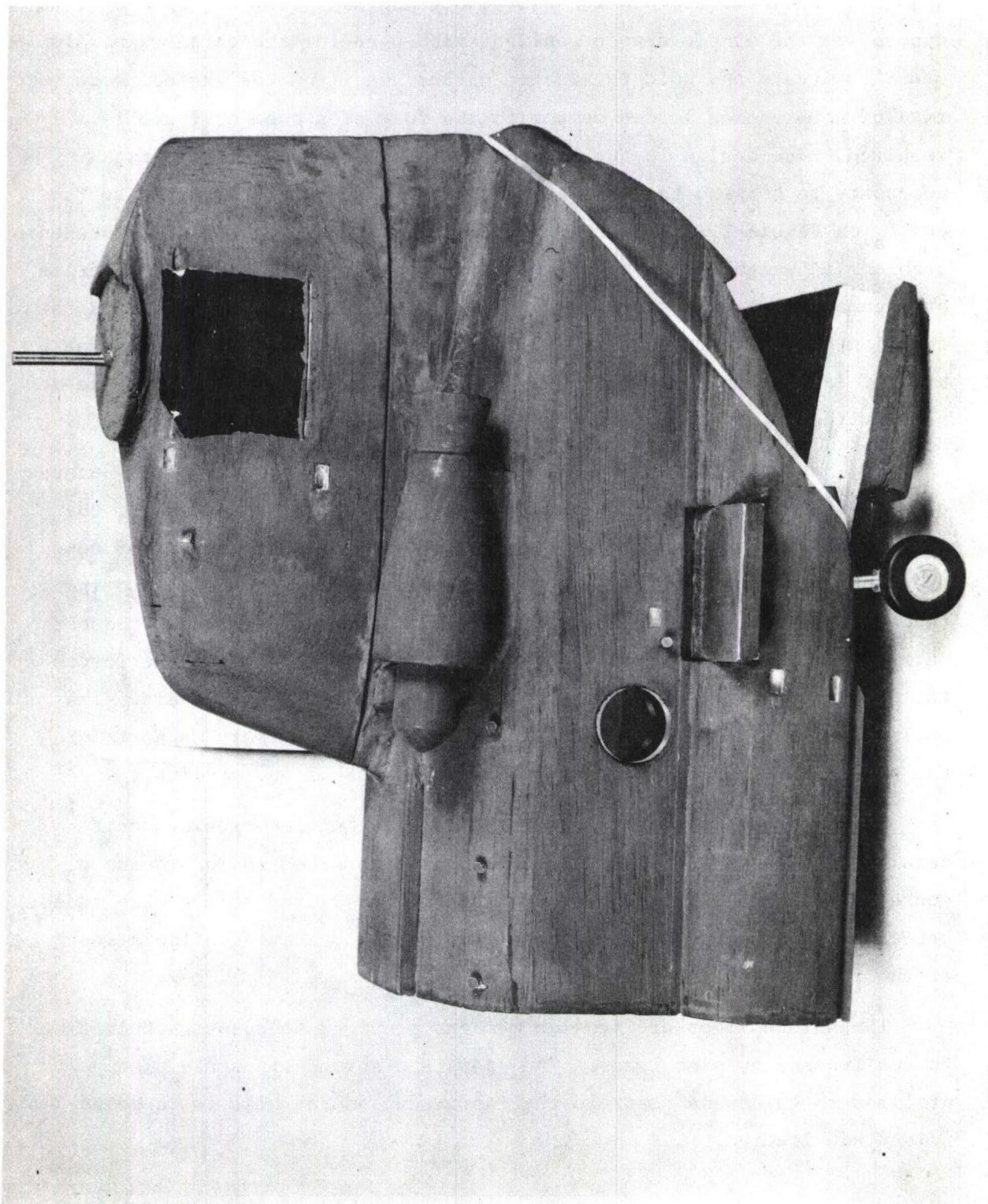


Figure 2.1. Ridge Line, Scale Model



nacelle fairing in the raised position. Figure 2.2 shows the development of the shelter outline to enclose the minimum working volume.

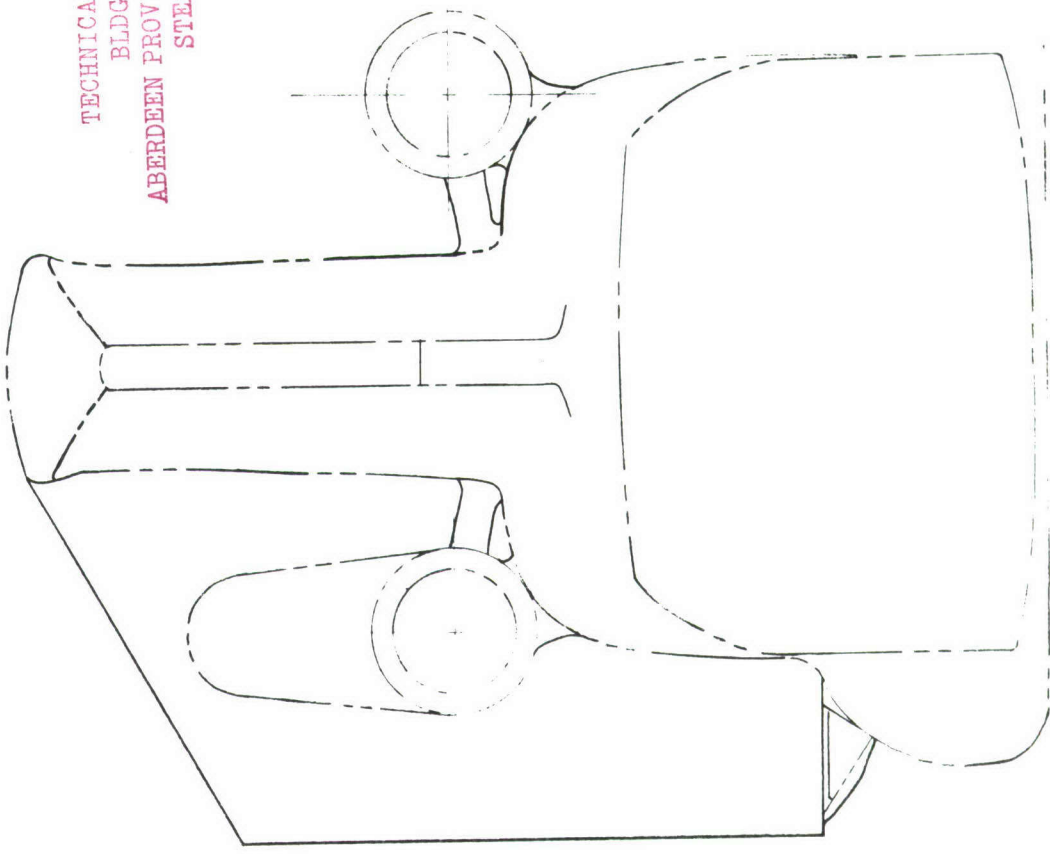
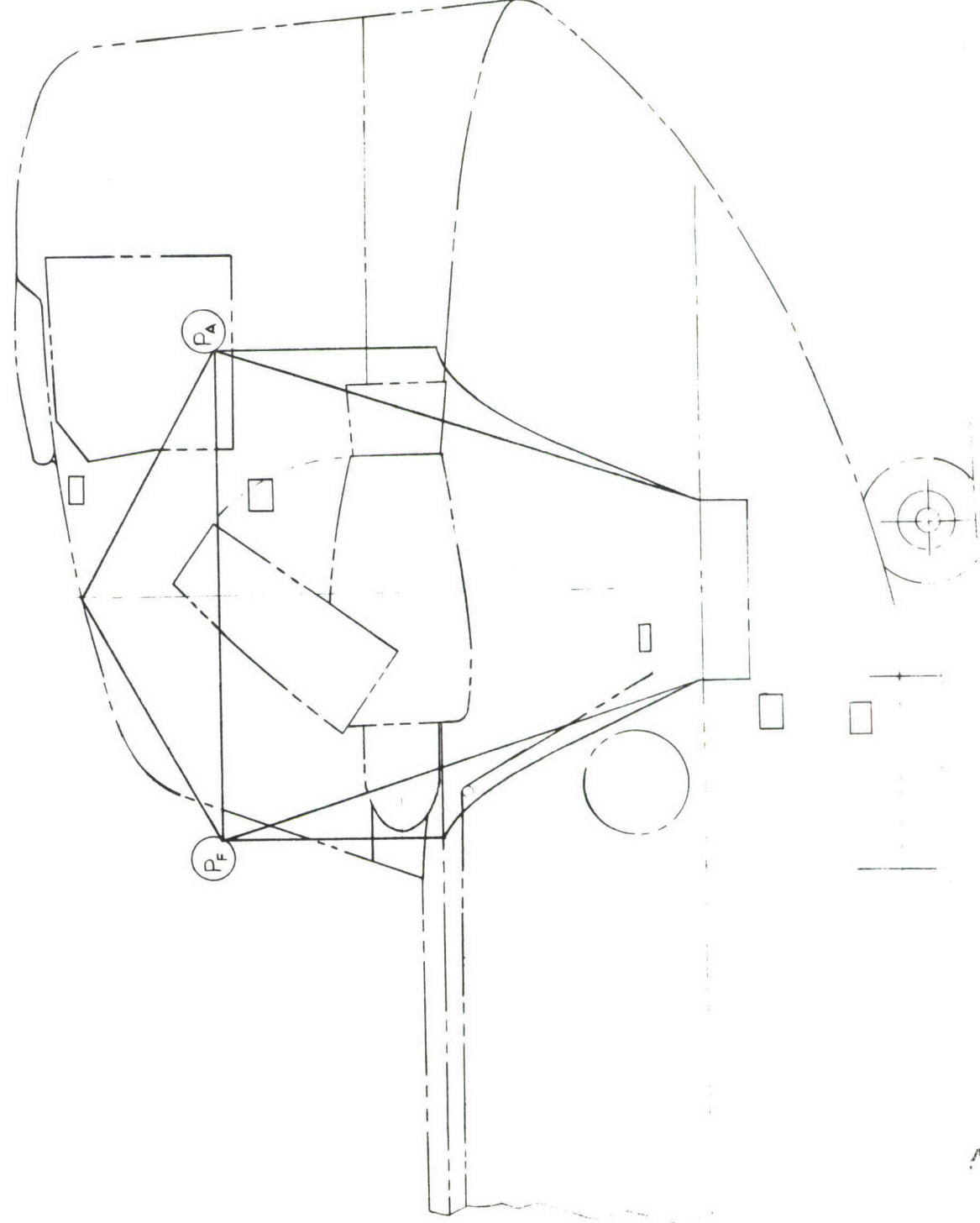
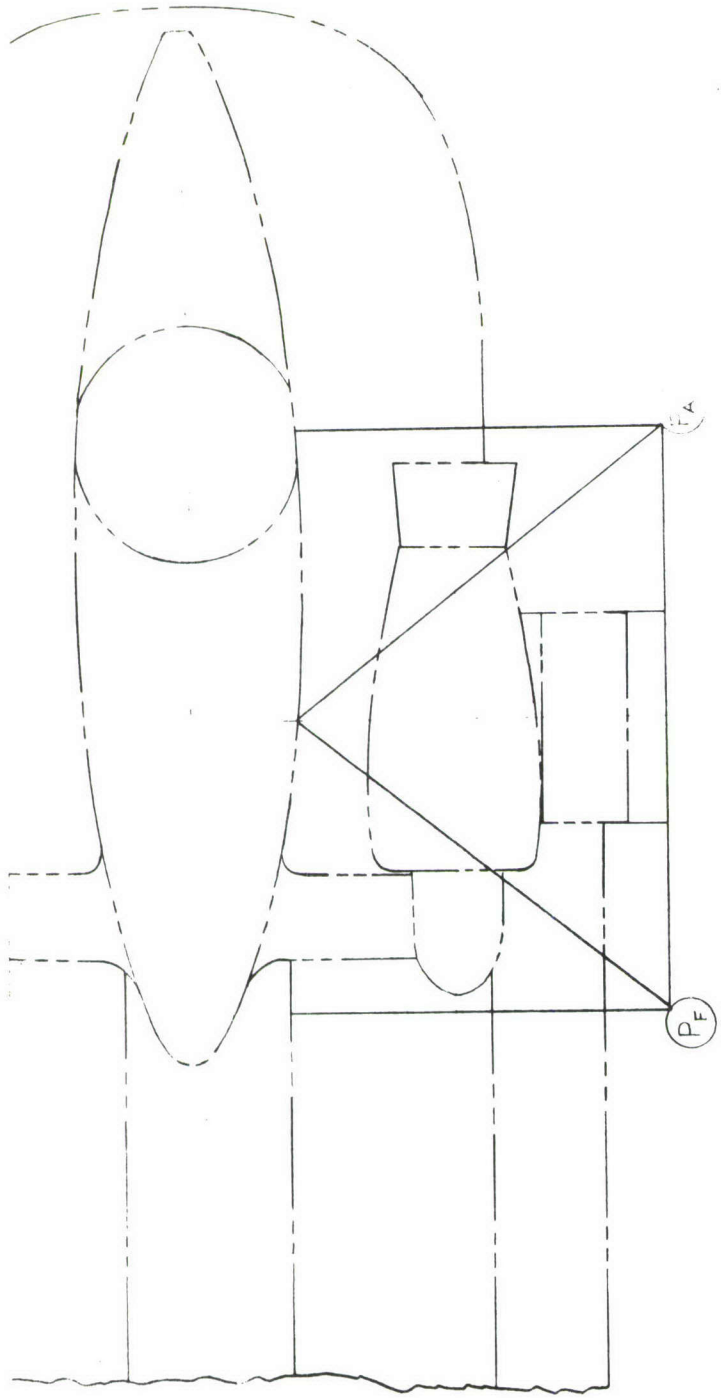
The first significant feature apparent in the engine shelter design was that the enclosure had to be held out and away from the fuselage, as opposed to the simple draped configuration used for the cargo ramp. In order to locate and hold the fabric up and away from the engine, some type of compression loaded member in the form of a boom or frame is required. The design layout locates a minimum of two remote points necessary to suspend the shelter envelope. These are designated as  $P_f$  and  $P_a$  on Figure 2.2. The requirement for a supporting framework presents problems in weight, bulk and complexity, however using an external frame arrangement also offers the advantage of a rigid member to assist in the erection of the fabric envelope. The design utilizes the framework as a kind of mast on which it is possible to raise and lower the tent like a sail, without losing control of it under high wind conditions.

The basic frame consists of the two spars and the crossbar. Because compression members are of necessity heavier than tension members, the intent was to design a framework with the least possible number of compression loaded columns. In the final configuration the spars are intended to be the only compression members. With the spars and crossbar carrying this load, it remains only to compensate for the moment forces that would cause the frame to rotate about the base of the spars. The guyline carries this load in tension. The minimum primary support for the enclosure then, consists of the spars, crossbar and guyline.

Tubular spars have been used to obtain the maximum resistance to bending with the least weight. Tubing was also selected to provide a socket for assembly with the other frame members. The struts were added principally to make the envelope conform to the concave configuration of the fuselage at the belt line.

The shroud lines are tension members provided to counteract lifting forces imposed by wind loads. The spars and shroud lines are also utilized to guide and restrain the fabric enclosure while it is being raised and lowered.





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Figure 2.2. Sketch, Working Volume Outline



An internal interlocking arrangement was devised, whereby the cross-bar locks the struts in the spar sockets. A totally enclosed lock was desired to prevent fowling by ice and snow.

The base bar maintains the position of the lower ends of the spars and distributes the compressive load from the spars over a large area of aircraft skin surface. A simple pin and slot combination provides a quarter turn locking of the spar to base bar.

The fabric enclosure is designed to be raised from the work platform along the shroud lines and spars, opened and clipped onto the struts and guy line. Entry to the work platform is by way of the existing hand and foot holds on the aircraft, and through a zippered opening. Top entry is through the forward roof side panel at the leading edge of the pylon.



### 3. DESCRIPTION OF PROTOTYPES

#### 3.1 CARGO RAMP ENCLOSURE

The cargo ramp enclosure is shown on the aircraft in Figures 3.1 and 3.2. It is a large trapezoidal shaped curtain like assembly consisting of eight basic panels and a number of ties and lines. Two large reinforcing panels are located on the inside where the cover comes in contact with the corner edges of the ramp.

The main support is the ridge line which consists of a 5/16 inch diameter rope and two short sections of shock cord. Polyester filament type rope was selected for maximum strength and flexibility, and is preferred over nylon because it does not continue to stretch under load. The elastic shock cord sections are included in each end of the line provide a limited degree of compliance for attachment. A special clip was designed to fit into the hole in the jack pad to secure the ends of the line. The ends of the line should be attached to points on the airframe that do not include the spring action of the landing gear strut.

A pair of polyethylene handles have been incorporated so that one man can hold the line up over the rear of the fuselage at the ramp opening, while the other secures the ends. The handles are fabricated from rod stock and are provided with molded contoured grips which reduce forearm and wrist fatigue.

The belt line ties include elastic cords and are terminated with hook ends for attachment to the hand hold openings just above the work platform.

Strap ties were provided for securing the enclosure in the wheel well areas, however, preliminary trials have indicated that these would be better replaced by elastic cords and hooks to eliminate the difficulty of trying while wearing gloves or mittens. The strap ties are fabricated from woven nylon strap stock.



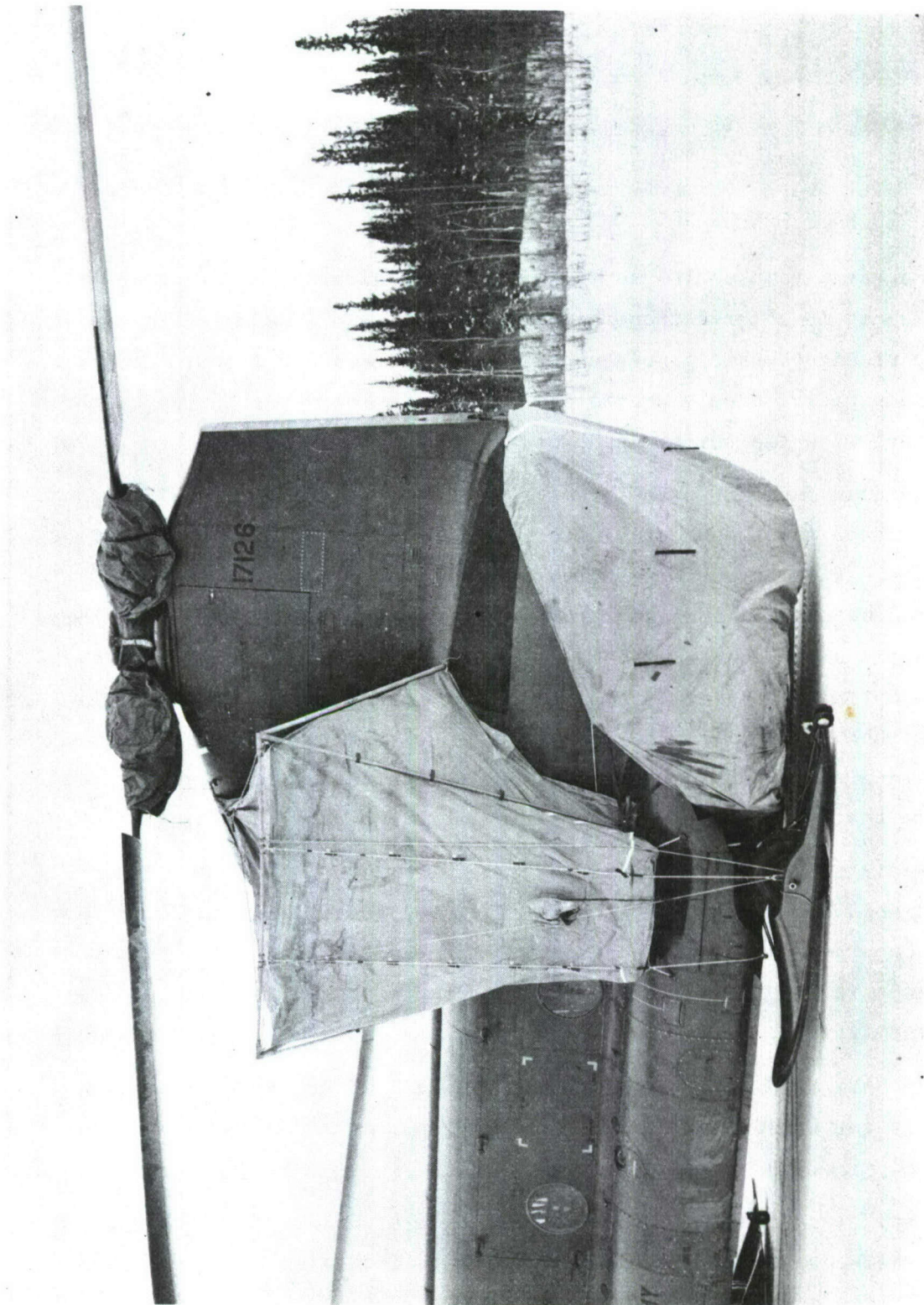


Figure 3.1. Engine and Cargo Ramp Shelters on Aircraft





Figure 3.2 Engine and Cargo Ramp Shelters on Aircraft



## 3.2 ENGINE SHELTER

### 3.2.1 Engine Shelter Frame

All of the structural frame components are fabricated from fiber-glass reinforced polyester. Figure 3.3 shows the complete frame erected on the helicopter. The two tubular spars are the main compression members. The upper end of the spar has sockets to receive the strut and the crossbar and establishes the proper angle for the strut. When the framework is assembled, the strut cone end is inserted first, then the crossbar is inserted to lock the strut to prevent it from falling out when the frame is raised. The sketch shown in Figure 3.4 was used to develop the configuration of the parts and illustrates the method of interlocking. The base of the spar is T shaped and designed to distribute the load regardless of the angle that the frame assumes. The proximal guy line is attached to the socket end of the spar by a large diameter ring which provides for flexibility and self alignment of the line under load. Additional compensation for alignment is provided by the limited sliding connection at the fork of the guy line.

Pulleys are mounted on the guy line rings at the spar sockets for the canopy haul up lines. The crossbar is a solid circular cross-section Fiberglass Reinforced Polyester (FRP) bar. Six triangular collars are permanently attached to the bar with an epoxy adhesive and serve to locate and retain the rings used for attachment of the various lines. The triangular shape was selected to prevent the haul up lines from being pinched and jammed while passing through the rings. The outer rings guide the moving haul up lines, the inner rings are used as points of attachment for the shroud lines and the crossbar safety cords. When the framework is assembled the safety cords are hooked onto the spar socket rings to prevent the crossbar from coming out of the socket and unlocking the strut.

The struts are also fabricated from Fiberglass Reinforced Polyester round bar stock and have stainless steel tips inserted in each end. The cone tip at the upper end was originally machined out of the Fiberglass



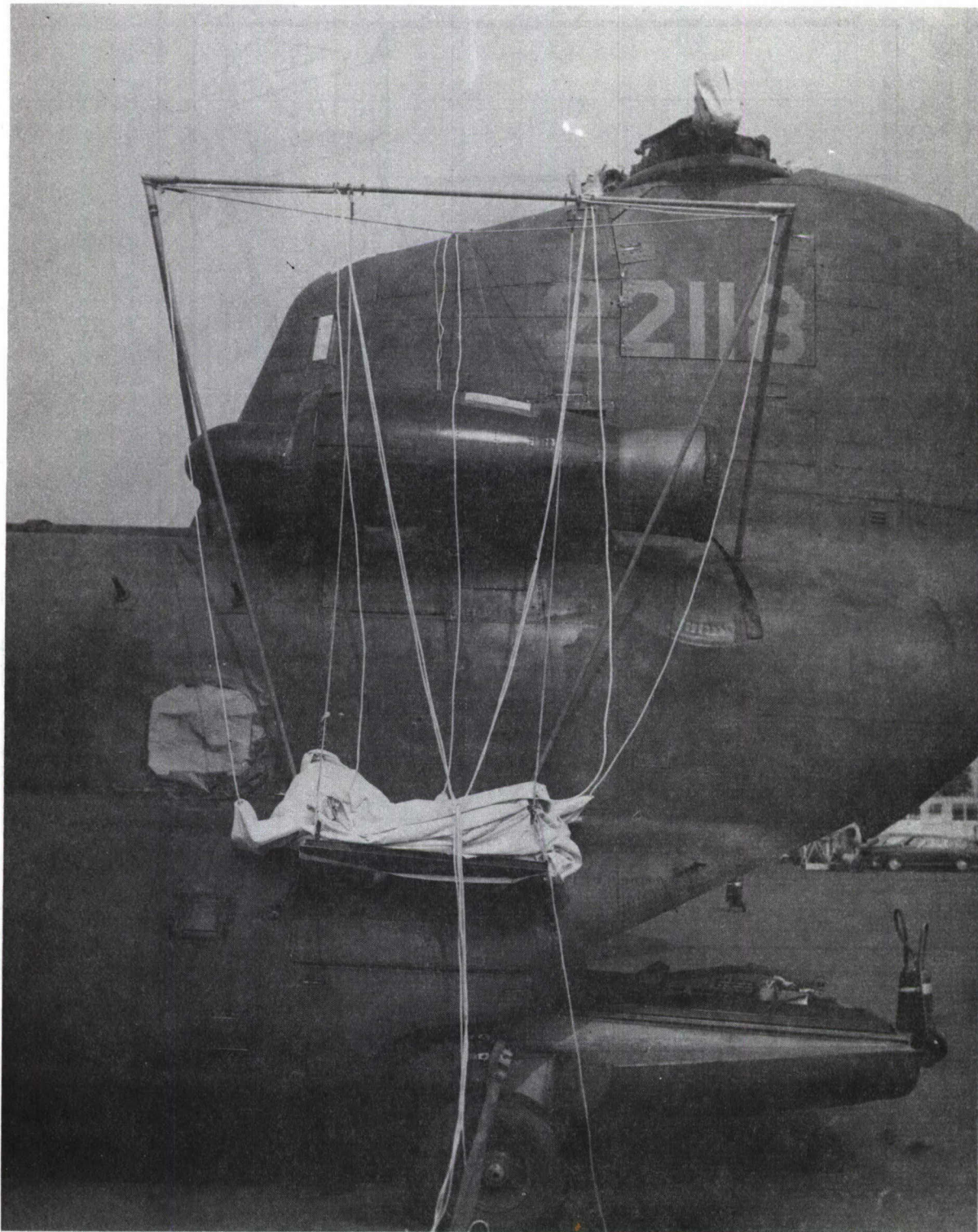


Figure 3.3. Engine Shelter Frame Erected on Aircraft



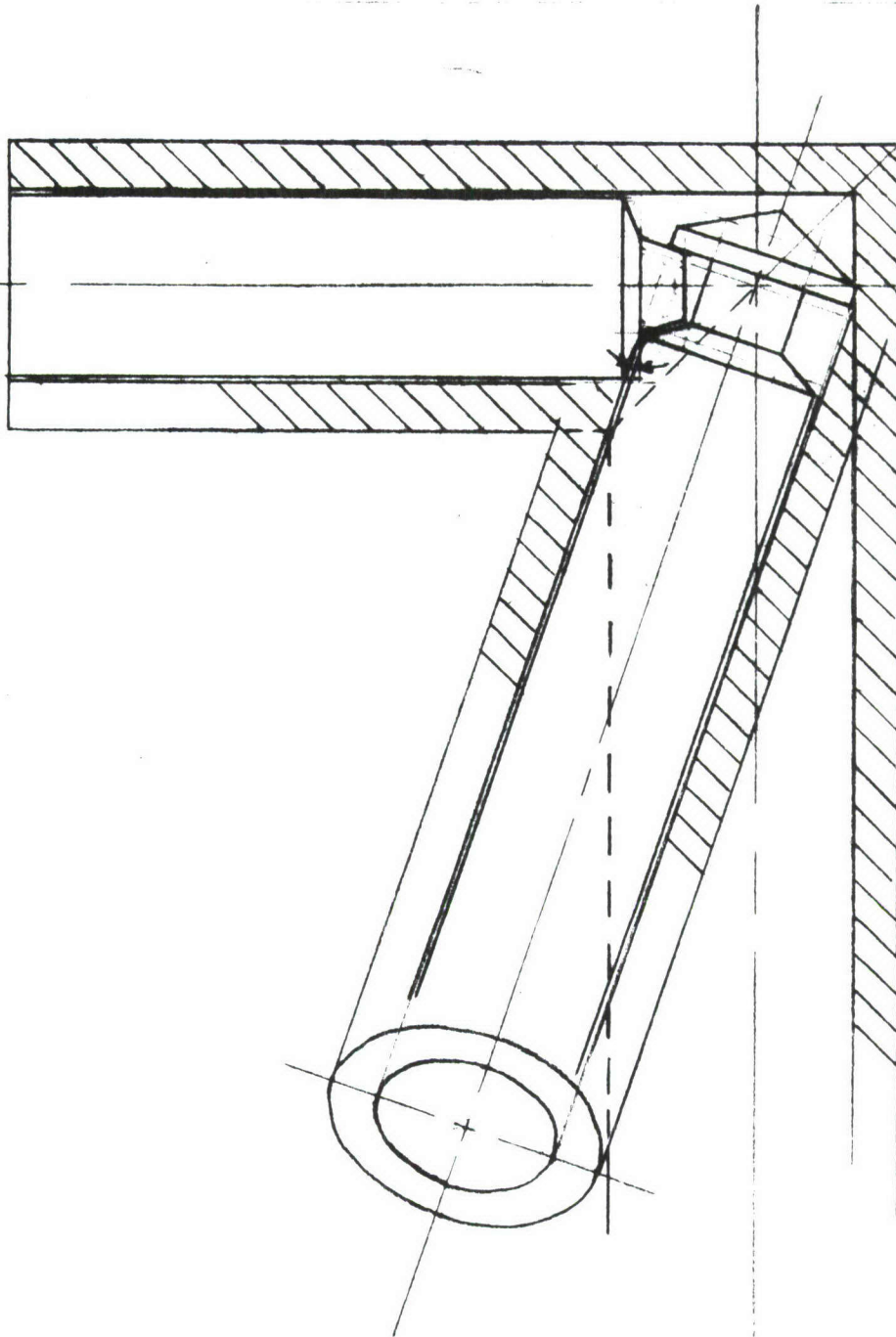


Figure 3.4. Sketch, Strut and Crossbar Interlock



Reinforced Polyester stock however, the edges of the cone chipped and cracked in use and the design was modified to increase the serviceability of the part. The tips are locked to the assembly with press fitted pins. The small depression at the upper end that is filled with red enamel is a safety indicator to show that the strut is fully engaged when assembled to the spar. When the strut is inserted into the spar socket to the full depth the red dot is not visible. The crossed pins at the bottom lock the strut into the base bar.

The base bar is made of hollow tubular Fiberglass Reinforced Polyester stock. Two slotted holes are machined into one side of the tube to accept the lower end of the struts. The crossed pin at the base of the strut will pass through the slotted hole and can be locked in play by rotating it 90 degrees. The strut should bear on the outside wall of the tube for support.

A pair of support arms machined from synthane sheet stock are designed to slide onto the base bar position at the fuselage belt line. The ends of the arms are notched to engage on the inner edge of the work platform.

Two base bar safety cords are designed to be passed around the base bar and hooked to holes located on the platform to keep the support arms engaged to the edge of the work platform.

The guy line is run up over the top of the pylon and secured around the engine on the far side. The guy line performs two basic functions. It is used as a hoist line to raise and lower the frame assembly and also to hold it in place against the side of the aircraft while the shelter is in use. A two-piece guy line is used so that the rope does not have to be dragged across the top of the pylon while hoisting, and also to allow the man on the top of the helicopter to be on the same side as the frame when it is being raised and lowered. This allows him to observe the position of the frame at all times and to see and talk with the man on the ground. The guy line separates at the top of the pylon. The proximal guy rope is threaded through a "D" ring at end of the guy



line and used for hoisting the structure. The section of the line that passes over the top of the pylon is fabricated from a wide nylon strap to distribute the load over a large area of the aircraft skin surface.

A harness fabricated from the wide webbing lays along the top of the pylon and is used to keep the guy line from sliding forward along the pylon.

### 3.2.2 Engine Shelter Canopy

The canopy is a tent like fabric envelope consisting of six panels. The shelter is shown installed on a helicopter in Figures 3.1 and 3.2. The entire enclosure is symmetrical about it's center line so that it can be used for either side. The lower platform entry and high voltage antennae slit is duplicated on each side.

A sleeve is provided on the side panel for connection to the Herman Nelson heater. Inside of the canopy a baffle panel sewn along the top and bottom edges deflects the hot air around the sides of the canopy and prevents it from blowing directly on the mechanic.

Heavy duty marine zippers molded of Acetal plastic are used for the lower platform entry.

Webb loops and D rings on the side panel contain and guide the canopy along the shroud lines and struts while it is being raised and lowered. Hooks have been provided along the roof side panel seams to secure the canopy to the spars and guy lines.

## 3.3 PRELIMINARY TESTING

Prior to shipping CH-47 shelters to Arctic Test Center Alaska for evaluation, USA LWL personnel visited Ft. Carson, Colorado to conduct field tests under cold windy conditions and to determine if the shelters could in fact be installed by individuals wearing Arctic clothing. Weather conditions during the test period consisted of temperatures ranging from 0 to 20°F with winds of 10 knots gusting to 15. Eight to ten inches of snow had accumulated the day prior to testing. Although weather conditions at Ft. Carson do not parallel conditions experienced by troops in the



Arctic, the tests did provide sufficient data for modification of shelters prior to shipment to ATC, Alaska.

The cargo ramp enclosure was installed with virtually no difficulty. This particular enclosure has been well received. Except for the arctic mittens, this enclosure can be readily installed while wearing arctic clothing. The only change made to the ramp enclosure was the addition of a bungee draw cord around the bottom which works similar to a draw string. This permits raising and lowering of the ramp without danger of tearing the fabric. This modification reduced the overall time to install the structure since the two midline ties and the two port crossties were no longer required.

Although it was possible to install the engine shelter while wearing arctic clothing, the overall shelter was complicated, confusing and required too much time to prepare for erection. Personnel from Ft. Carson stated that they did not believe that anyone would take the time to erect the engine shelter in its present form. Upon returning to APG, the following modifications were made prior to shipping the shelter to ATC, Alaska.

1. Two lengths of bungee cord were provided to attach the base bar to the work platform. This reinforced the entire structure.
2. The shroud lines were made captive to the canopy "D" rings, eliminating the need for threading each shroud line through the four "D" rings.
3. A draw string principle, using bungee cord, snap and hook was provided to envelope the canopy around the bottom of the work platform.
4. The pylon harness and distal guy lines was also integrated which eliminated the need for threading the guy line through the pylon harness.
5. Most ties were removed and replaced with short sections of bungee cord since the ties were difficult to tie with arctic mittens.
6. All components were stenciled and/or marked for easier identification.



Although the Ft. Carson field test demonstrated the need for numerous minor modifications and improvements to simplify and reduce erection time, it is felt that a more comprehensive field evaluation in Alaska will ascertain the need for additional modifications based on environment and extended field use.



#### 4. OPERATING PROCEDURES

##### 4.1 ENGINE SHELTER ERECTION PROCEDURE

###### 4.1.1 Development

Figure 4.1 shows the development of the component parts of the shelter as laid out on the ground next to the aircraft in preparation for assembly and erection. Note that the forward and aft support arms are so marked, the forward arm is the longer and is always located on the forward end of the base bar. Lay the struts down with the cone tips pointing away from the aircraft. The spars should be laid down with the crossbar sockets facing each other and the strut socket down. Lay the guy line out away from the framework. Slide the guy line thimbles at the strut socket, around so that they will pull up on the top of the rings when the frame is hauled up. The canopy line pulleys should be in the area of the apex of the sockets.

###### 4.1.2 Assembly and Erection

1. Slide the support arms onto the base bar. The longer arm, marked "forward" must be located on the base bar toward the end that is closest to the front of the aircraft.
2. Insert each strut through three loops on the canopy. The loops are marked L and R for left and right and are numbered, and color coded orange. The strut should be passed through the loops so that number one is toward the cone end of the strut and numbers two and three are closer to the aircraft in that order.
3. Insert the cone end of each strut in the strut socket on the upper end of the spar.
4. Insert the cross bar into the cross bar socket of one spar. When the strut and cross bar are fully inserted into their respective sockets, the cross bar locks the strut in place. If the strut has not been locked in, withdraw the cross bar about one inch and check the strut for full depth insertion into the socket. When fully inserted, the red dots near the end of the



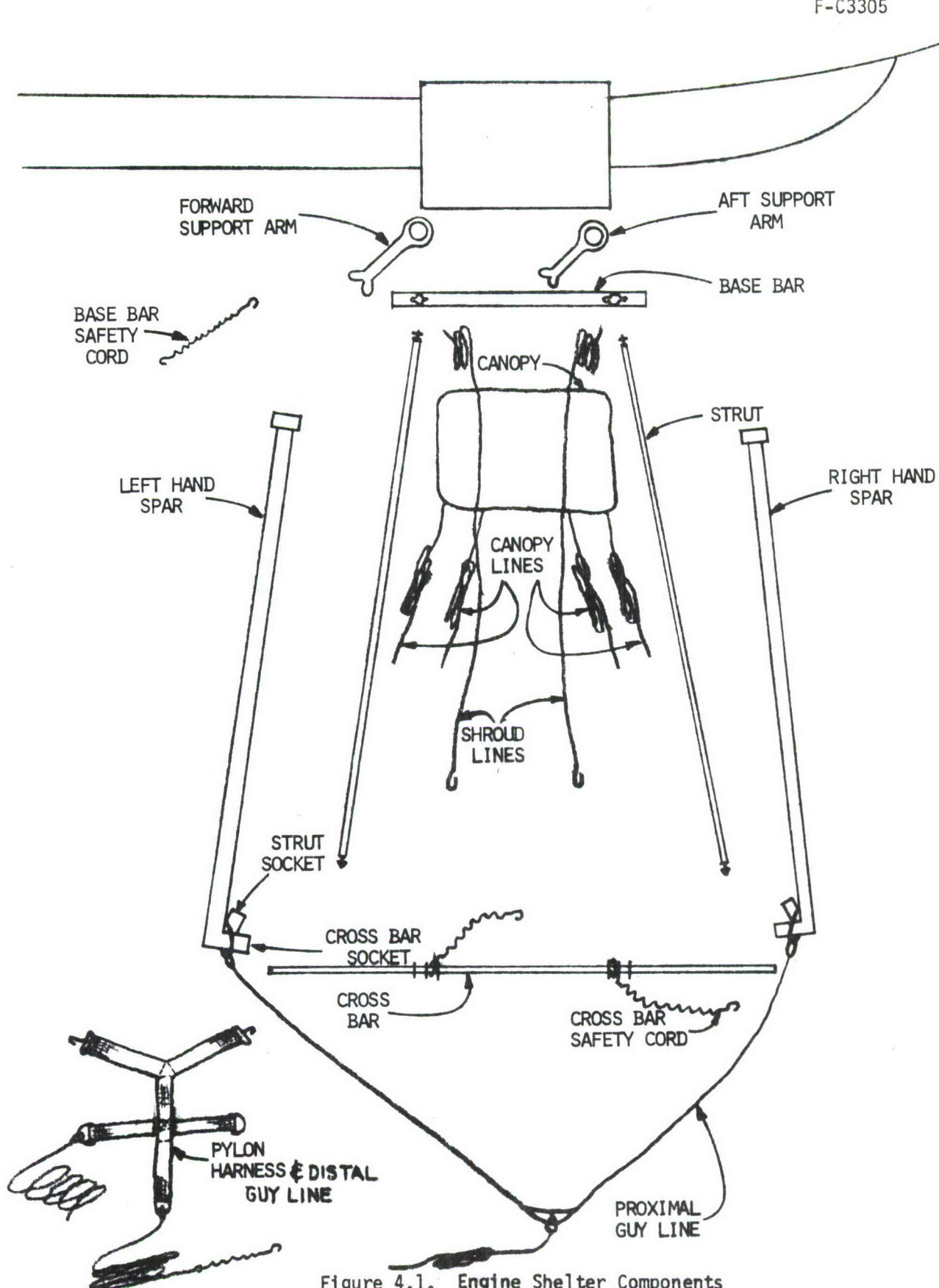


Figure 4.1. Engine Shelter Components



strut will not be visible. Assemble the other strut and spar with the cross bar.

5. After both struts and spars and the cross bar have been assembled, lock the cross bar in place by clipping the cross bar safety cords between the strut socket rings and the shroud line rings.
6. Insert the bottom end of one of the struts into the keyed hole in the base bar. Rotate the strut one quarter turn to lock it in place. Insert the other strut in the same manner.
7. With the lower work platform opened and locked in place, lift the frame and set the base bar on the aircraft at the belt line and the top of the frame on the ground. The canopy should be laid on the work platform.
8. Position the open ends of the support arms on the inner edge of the work platform. Loop the base bar safety cords around the base bar and clip the ends to the aircraft structure in the platform well.

At this point one man can continue with the assembly on the ground while the other climbs up on the aircraft to install the pylon harness and distal guy line.

9. Thread the green canopy lines through the cross bar rings that are next to the shroud line attaching rings.
10. Thread the yellow canopy lines through the spar pulleys then through the cross bar rings with the green lines.
11. On top of the aircraft, the upper ends of the "Y" shaped pylon harness should be clipped into the upper most pylon hand holds. The harness should be run along the center ridge and leading edge of the pylon and the shock cord on its lower end clipped into the slot at the leading edge of the base of the pylon.
12. The webb end of the distal guy line should be on the shelter side of the aircraft while the opposite end is looped around the engine nacelle on the far side, and tied to the far side "D" ring so that the distance from the center of the pylon to the "D" ring on the shelter end is approximately 18 inches.
13. The man on the ground should throw the proximal guy line up to the man on top of the aircraft. Thread the proximal guy line through the "D" ring in a downward direction, and take up the slack in the guy line.
14. With the man on the ground lifting the crossbar and the man on top hauling on the guy line, commence raising the frame.



When the crossbar reached the limit of the reach of the man on the ground, he should move to a position where he can continue to guide the framework by holding onto the struts. Guide the bearing ends of the spars past the ends of the engine till they come to rest on top of the aircraft along the line at the base of the drive shaft tunnel cover. The forward spar should be in front of the turbine shaft fairing. Tie the guy line securely and check the security of the distal section again.

15. Group the green and yellow canopy lines together and raise the enclosure up to the crossbar. Watch to see that the loops on the struts do not become fouled. When the enclosure has been raised evenly to all points, secure the canopy lines to the landing gear shackle and snap the shroud lines to the rings on the crossbar. Attach other ends of shroud lines to jack pads.
16. Thread the line from the apex of the top panel through the small "D" ring on the pylon harness just aft of the guy line, and tie it securely.
17. Attach the canopy hooks to the spars and to the proximal guy line to support the top of the enclosure.
18. The enclosure can be tied through the center of the bearing ends of the spars.
19. Using the bungee snap/hook provided at the bottom of the canopy, pull similar to a draw string, and attach snap and hook under the work platform.
20. Grommets and ties are also provided so that the canopy material can be pulled under the base bar and tied into the belt line.
21. A slit and tie arrangement is provided to fit the enclosure around the high voltage antennae.
22. Other small lengths of bungee are provided at top of shelter which can be secured to various hand holds on the aircraft.

#### 4.1.3 Striking the Shelter

1. Untie the enclosure where the high voltage antennae passes through.
2. Remove the heater connection if it was used.
3. Close the work platform zippers.
4. Untie and free the canopy material at the base bar.
5. Disconnect bottom of the enclosure.



6. Disconnect bungee cord at the base of the spars.
7. Disconnect the hooks from the proximal guy lines and from the spars.
8. Untie the top panel apex line and drop the top so that all of the panels are hanging vertically.
9. Untie the canopy lines and lower the enclosure to the work platform.
10. Disconnect the shroud lines.
11. Untie the proximal guy line from the distal guy line at the "D" ring and lower the frame away from the aircraft with one man on the ground to guide it.
12. Drop the proximal guy line to the ground.
13. Untie the distal guy line from the far side engine nacelle and remove the pylon harness.
14. Disconnect the base bar safety cords.
15. Lift the frame off of the aircraft and place it on the ground.
16. Rotate each strut one quarter turn and remove the base bar.
17. Remove the support arms from the base bar.
18. Pull the canopy lines out of the rings and pulleys.
19. Disconnect the crossbar safety cords, and pull the crossbar out of the spar sockets.
20. Pull the struts out of the spar sockets.
21. Pull the struts out of the canopy loops.

## 4.2 CARGO RAMP COVER INSTALLATION PROCEDURE

### 4.2.1 Assembly and Erection

1. Lower the cargo ramp to the desired level for maintenance and retract the apron fully.
2. Open the packed cover enough to locate the ends of the ridge line.
3. Connect bungee cord of one end of the ridge line to the hole in one of the rear jack pads or snow skids.
4. Standing directly at the rear center of the aircraft, use the lift handles to position the ridge line and top of the cover up over the trailing edge of the fuselage above the cargo ramp opening.
5. Connect other end of ridge line (bungee cord) to opposite jack pad or snow skid.



(PORT SIDE INSIDE VIEW)

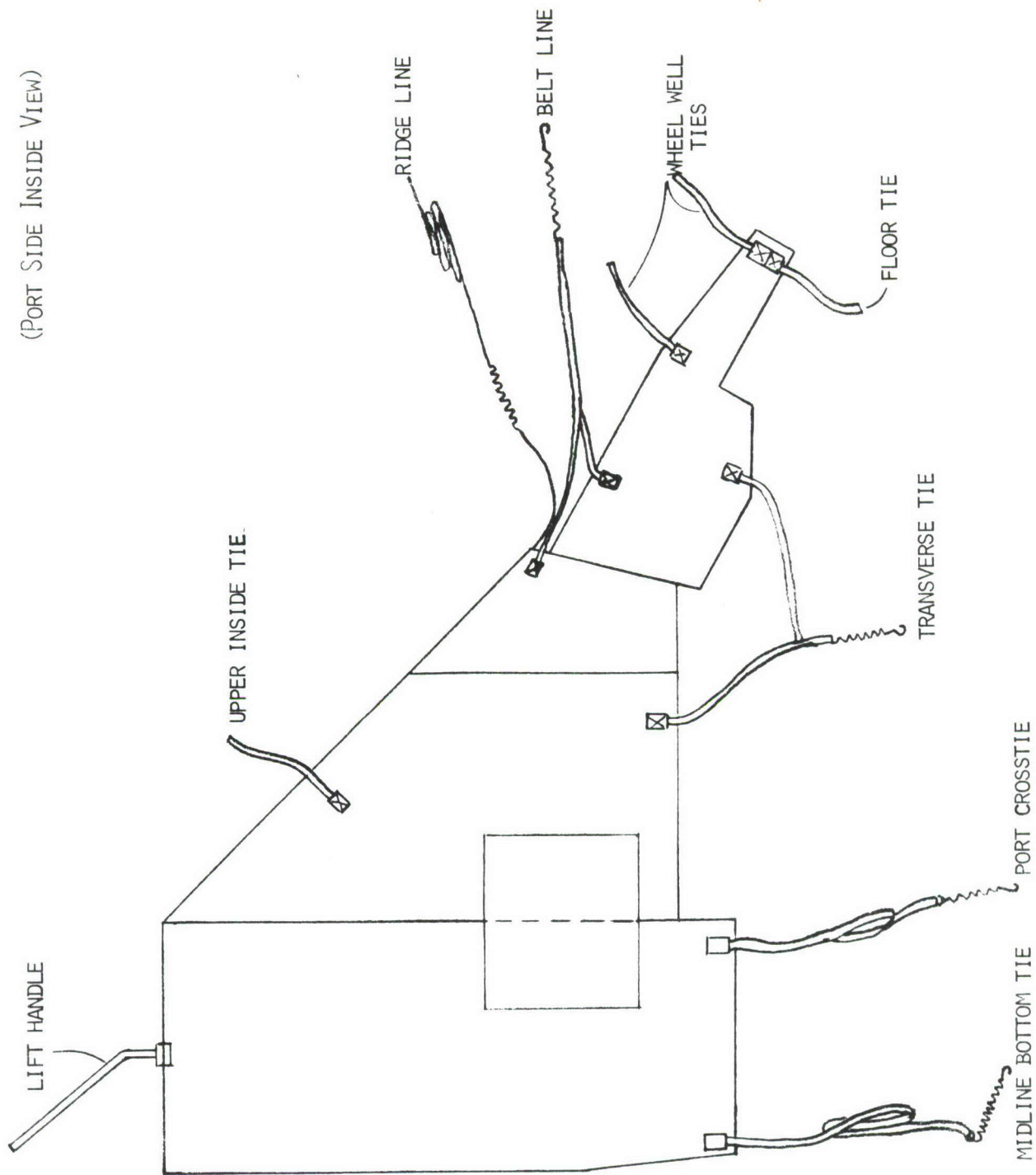


Figure 4.2. Cargo Ramp Cover



6. Be sure cover is centered at the rear of aircraft.
7. Hook the ends of the belt lines into the hand holds just above the lower work platforms.
8. Attach one end of bungee cord at bottom of cargo ramp cover to snow skid.
9. Attach other end of bungee cord to opposite side of aircraft.
10. Pull the transverse tie line under the ramp and secure to "D" ring on opposite side.
11. Inside the aircraft secure the floor tie lines to the rear cargo tie down rings in the cabin floor.
12. Secure the wheel well ties to the inside structure by threading them through the closest lightening holes.
13. Secure the inside upper ties through the closest lightening holes.

#### 4.2.2 Striking the Cargo Ramp Enclosure

1. Untie the inside upper ties.
2. Untie the wheel well ties.
3. Untie the floor ties.
4. Untie the transverse ties.
5. Unhook the belt lines.
6. With one man holding the lift handles, the other should disconnect one end of the ridge line from the jack pad or snow skid.
7. Allow the cover to fall to the ground and disconnect the other end of the ridge line.



## 5. MAINTENANCE

### 5.1 CLEANING AND REPAIR

The most common maintenance required in normal service will be cleaning oil, dirt and hydraulic fluid from the fabric and lines. This can be done by washing the parts with ordinary detergent and warm water.

Repairs will generally be limited to the replacement of ropes and lines and mending of tears in the fabric. Fabric tears should be repaired by sewing on patches by hand or with a standard sewing machine.

### 5.2 PACKING PROCEDURE

After the shelter has been used and particularly if it has been exposed to precipitation, it should be returned to a closed building such as a hanger or rigging loft to be opened up, dried, inspected and repacked. The packing area should be clean and within a temperature range of 60 to 85°F and a humidity range of 30 to 60%.

#### 5.2.1 Folding the Cargo Ramp Enclosure

Lay the enclosure out flat on clean surface with the inside facing up. Fold the ties and lines over and lay them on the fabric. The inside and stow ties should be laid out pointing toward the top of the enclosure. The lift handles should be laid out off of the fabric.

1. Fold the end panels in toward the center as shown in Figure 5.1.
2. Fold the bottom of panels No. 1 up as shown in Figure 5.2.
3. Continue to fold as shown in Figure 5.3 sections approximately 10 inches wide up to the stow ties, then tie the inner and outer ties to hold the folds in place.
4. Fold the ends in toward the center as shown in Figure 5.4.
5. Fold the ends in again as shown in Figure 5.5.



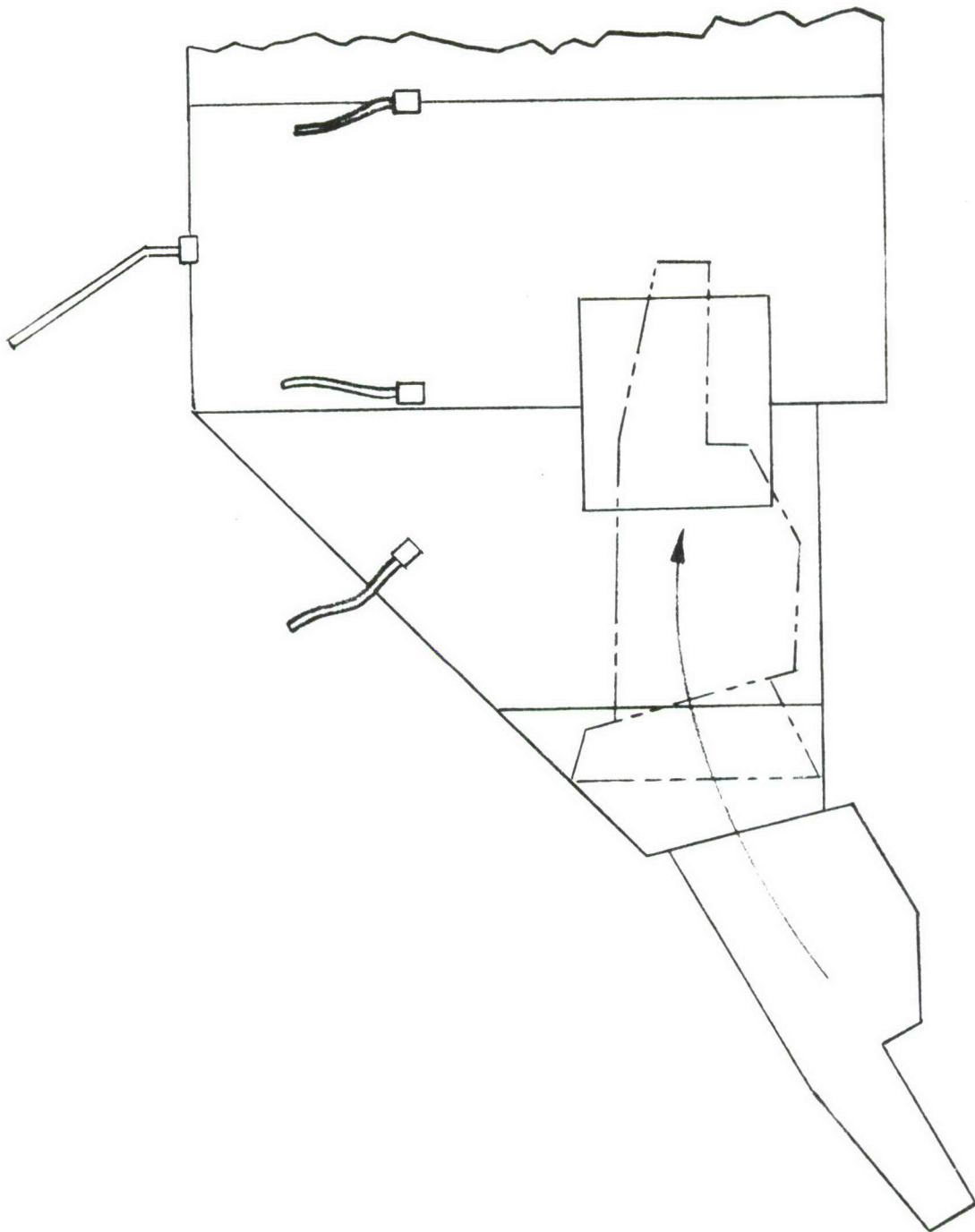


Figure 5.1



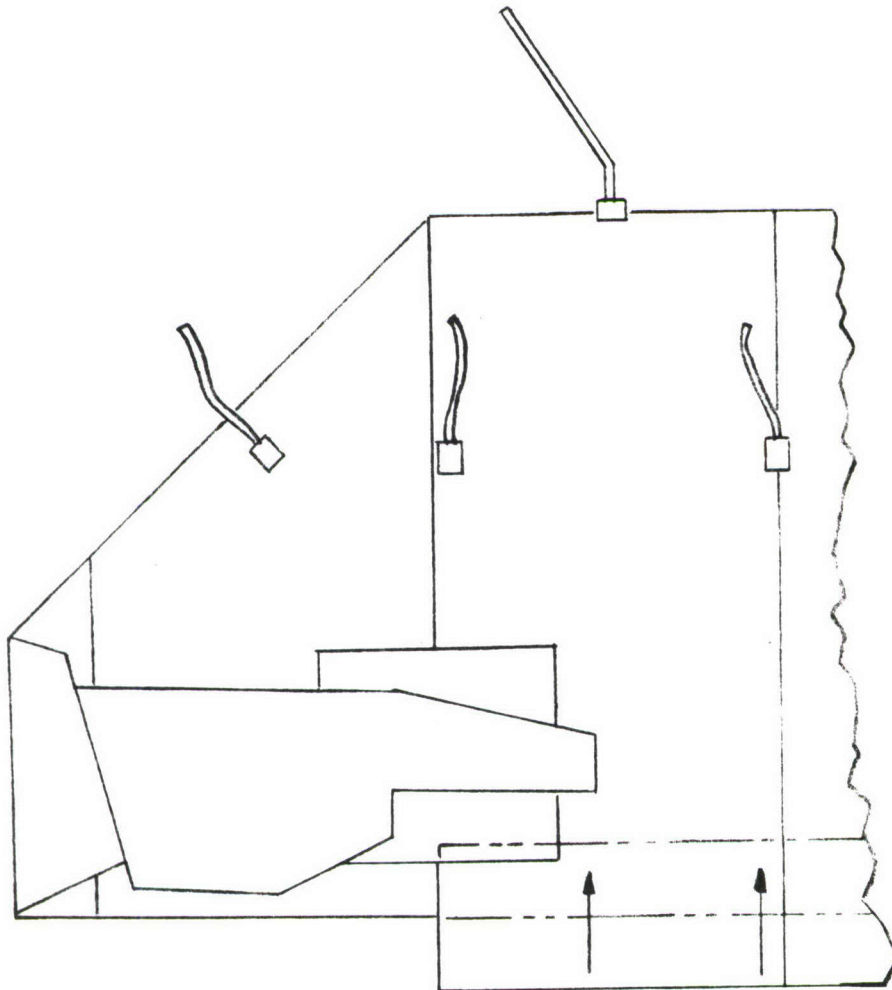


Figure 5.2



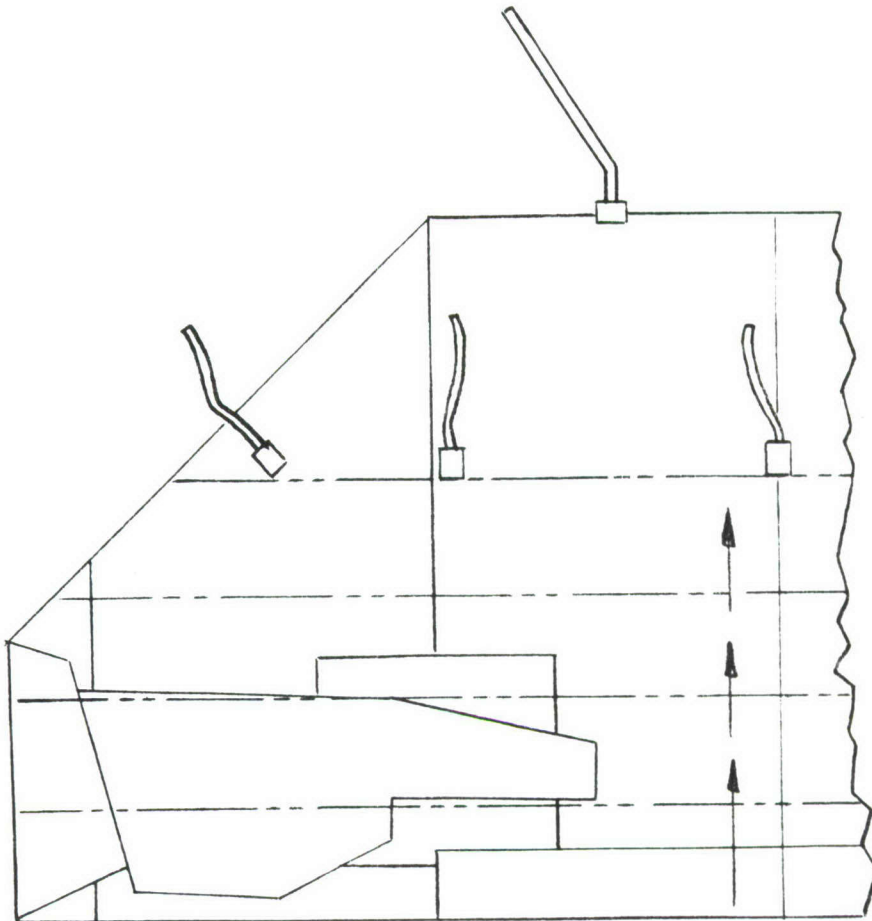


Figure 5.3



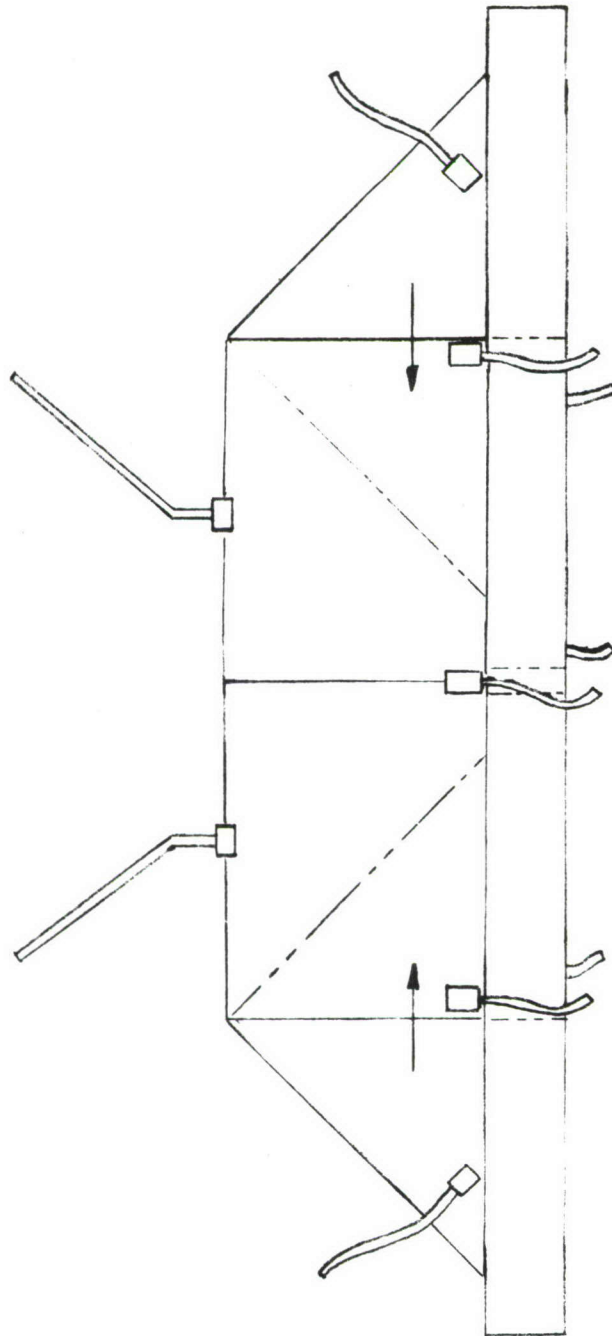


Figure 5.4



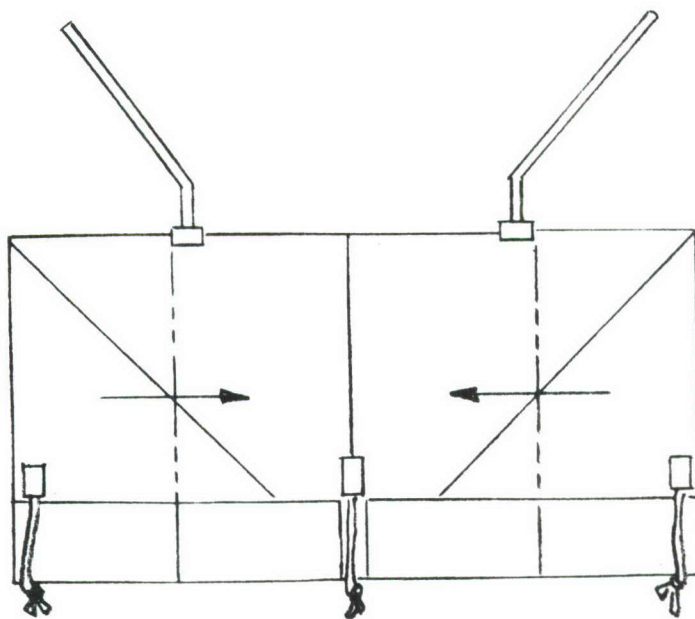


Figure 5.5



6. Fold in half as shown in Figure 5.6 then fold up in quarters to complete the package.

### 5.2.2 Folding the Engine Shelter Canopy

Layout the canopy flat on a clean surface with the inside facing up and the roof top panel folded in as shown on Figure 5.7.

1. Fold the side panels in as shown on Figure 5.8.
2. Fold the bottom up to loops R3 and L3 as shown in Figure 5.9.
3. Fold the top down to loops R1 and L1 as shown in Figure 5.10.
4. Form an accordian fold so that loops R1, thru R5 and L1 thru L5 are together. All loops should be at the outer ends and "D" rings at the bottom edge as shown in Figure 5.11.
5. With Rings R1 and L1 on top, fold the ends in as shown in Figure 5.12 and finally fold in half.



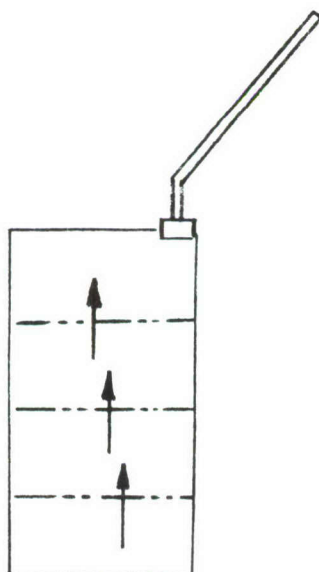
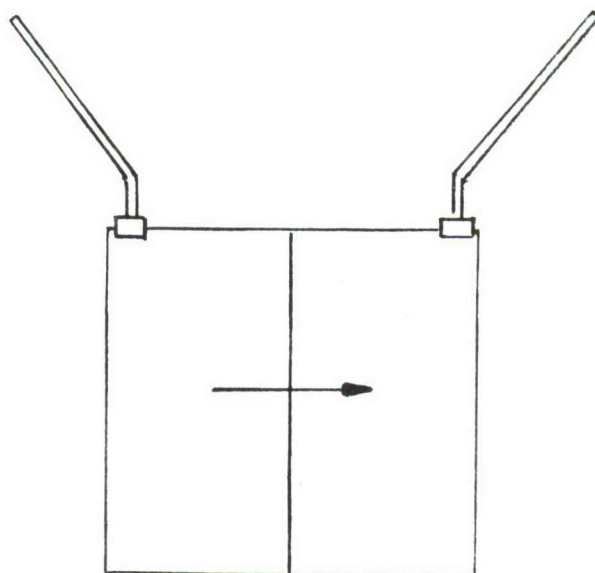


Figure 5.6



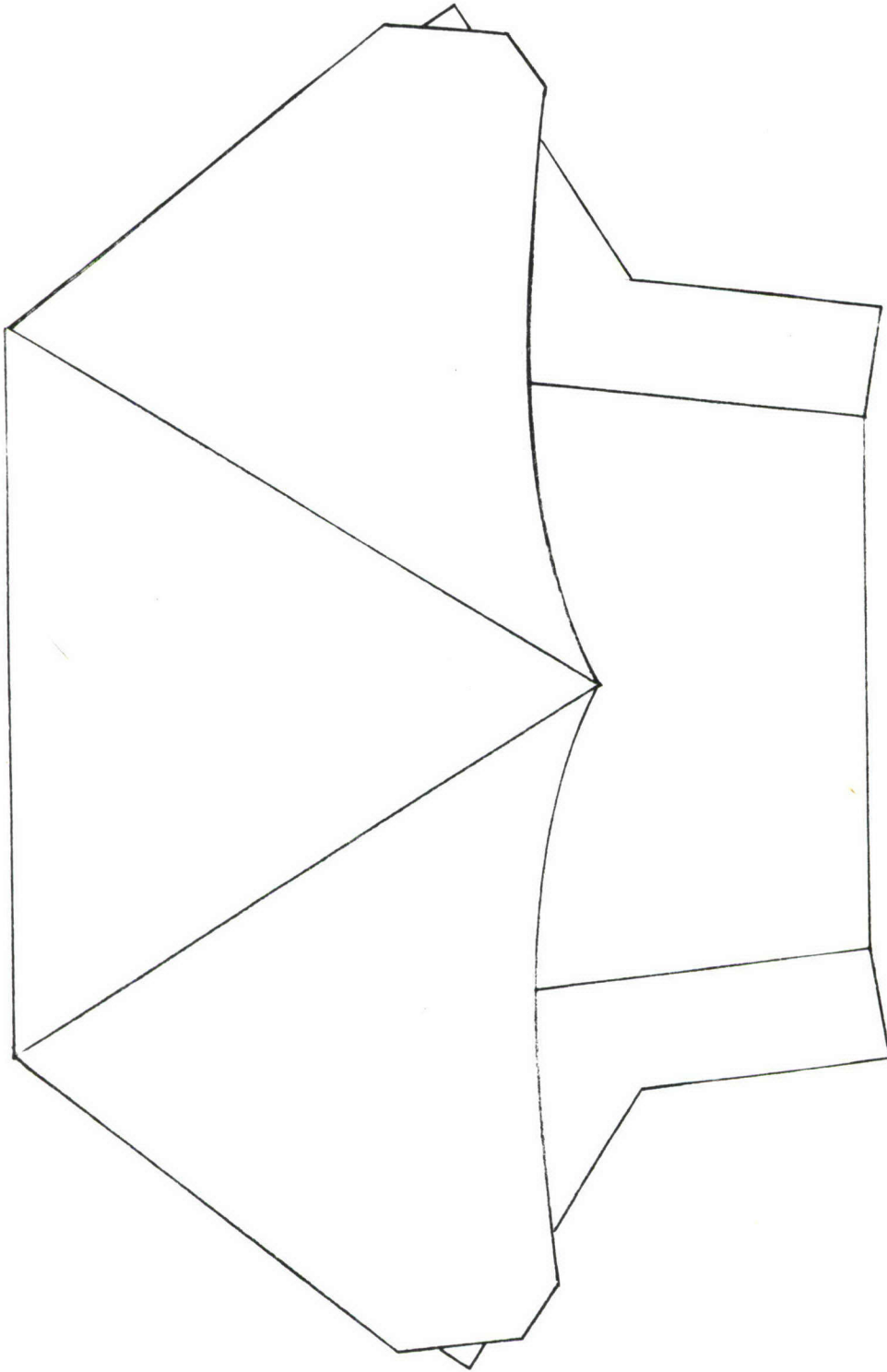


Figure 5.7



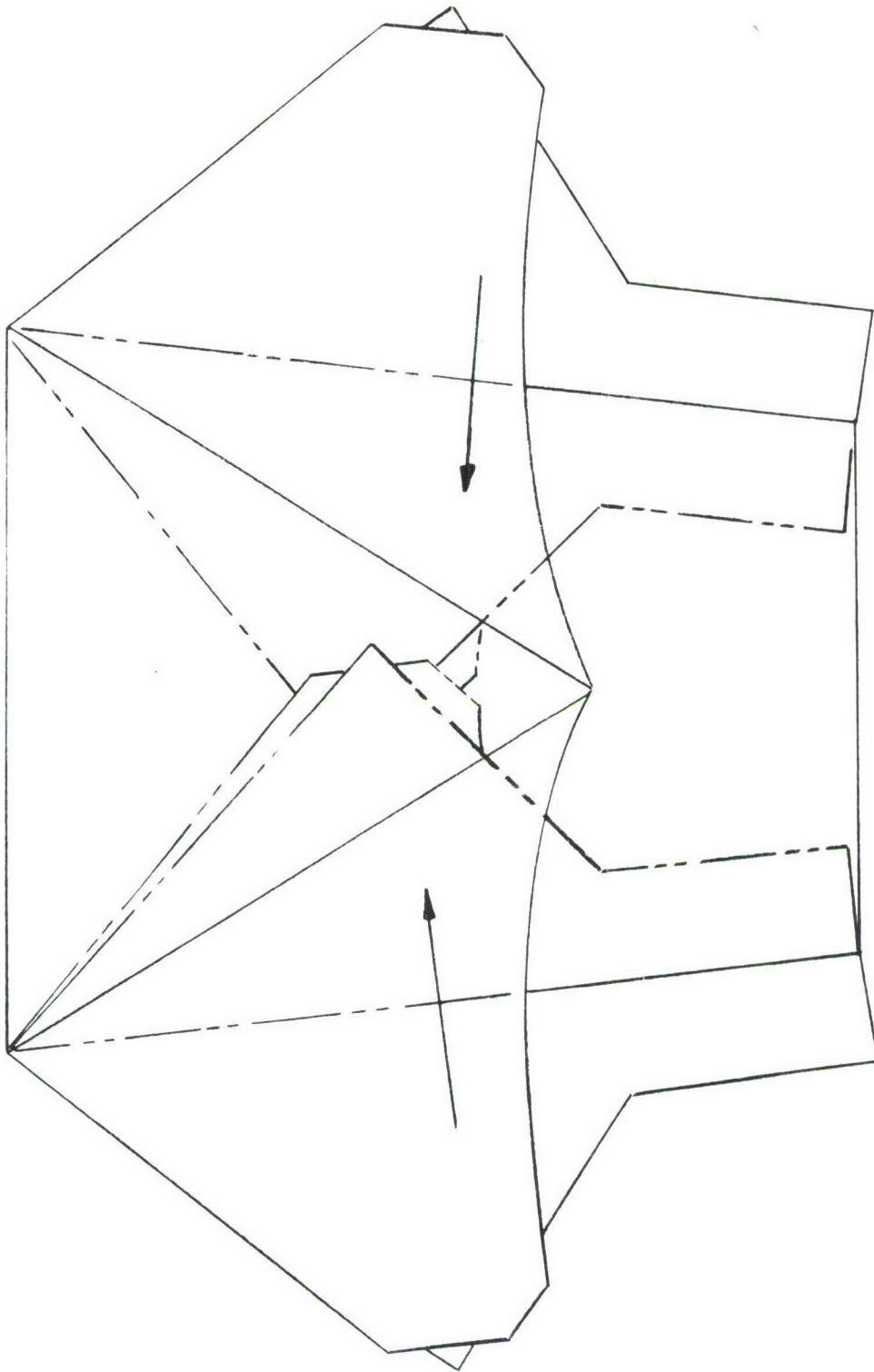


Figure 5.8



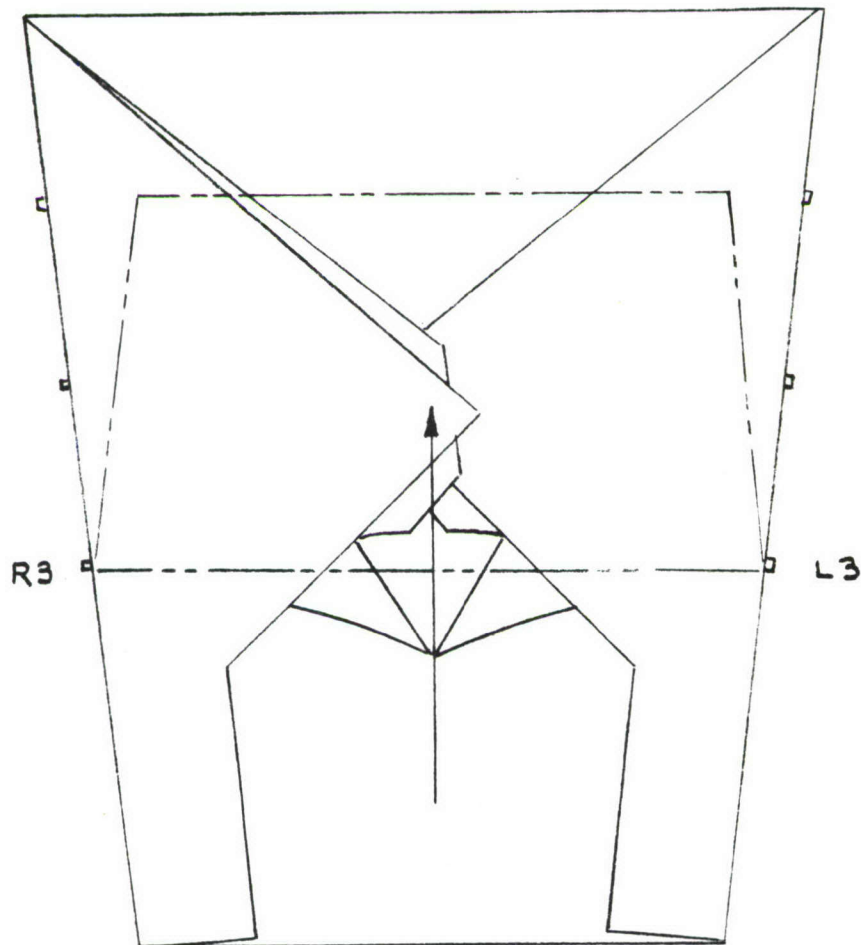


Figure 5.9



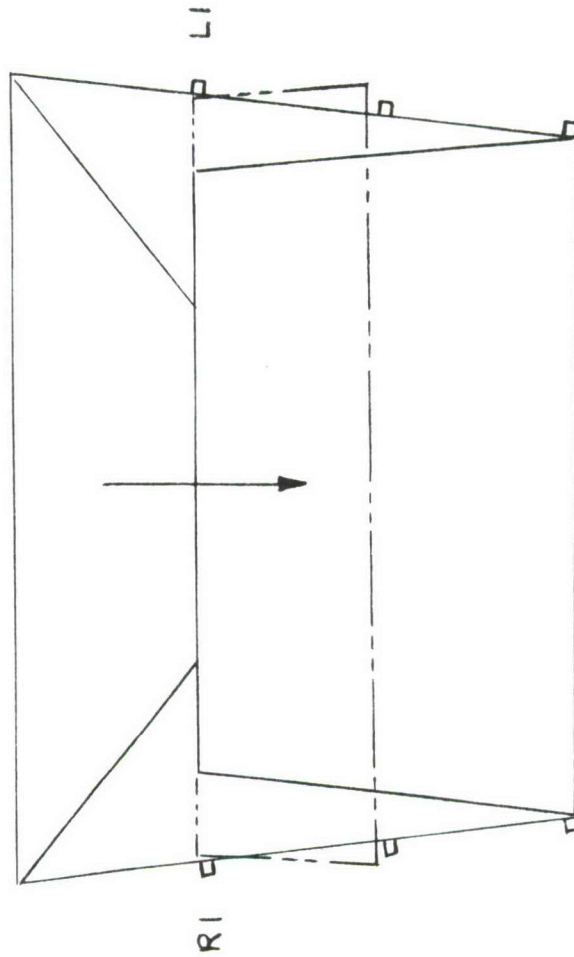


Figure 5.10



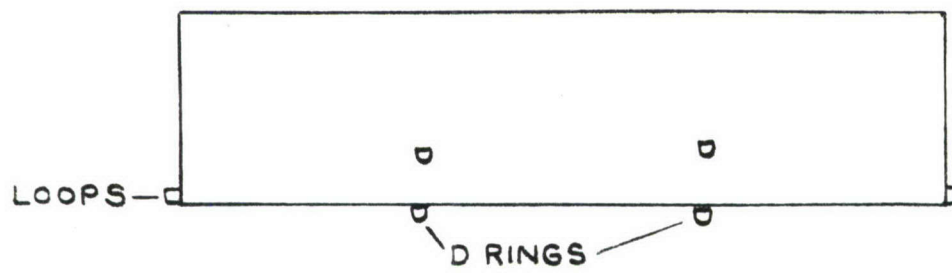


Figure 5.11

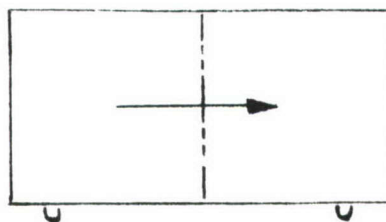
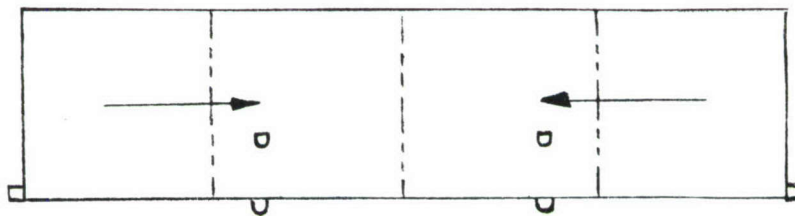


Figure 5.12



## 6. DESIGN SPECIFICATIONS

## 6.1 DRAWING LIST

Title	Number
Engine Shelter Canopy Assembly	D060050000-1/2
Side Panel Subassembly	D060050001
Spar Subassembly	D060050003
Crossbar Subassembly	D060050004
Base Bar	D060050005
Cargo Ramp Assembly	D060050100-1/2
Distal Guy Line	C060050006
Elastic Cord Tabulation	C060050007
Strut Subassembly	C060050008
Strut Details	C060050009
Crossbar Details	C060050010
Spar, Right Side	C060050011
Spar, Left Side	C060050012
Support Arm	C060050013
Strap Hook	C060050014
Roof Top Panel Pattern	C060050015
Roof Side Panel Pattern	C060050016
Side Panel Pattern	C060050017
End Panel Pattern	C060050018
Spar Hook	C060050019
Guy Line Hook	C060050020
Panel #1 Pattern	C060050101
Panel #2 Pattern	C060050102
Panel #3 Pattern	C060050103
Lift Handle	C060050105
Jack Pad Hook	C060050106



## 7. PROPOSED EVALUATION PLAN

### 7.1 REFERENCES

1. Draft Proposed SDR, USARAL, 7 August 1970, Emergency Repair Shelter for the CH-47 Helicopter.
2. Draft Proposed SDR, USACDC, 30 April 1971, Emergency Repair Shelter for the CH-47 Helicopter.
3. Department of the Army Approved Materiel Need for the Emergency Repair Shelter for the CH-47 Helicopter, CDOG Paragraph 169n(6), 19 June 1972.

### 7.2 INTRODUCTION

A shelter, designed to protect individuals during emergency repairs of the CH47 Helicopter in the field, is required. During arctic winters it is almost impossible to repair equipment without protection from the elements. Although the Department of the Army Approved Materiel Need is written to provide a complete shelter for emergency repairs of the CH-47 Helicopter, the U.S. Army Land Warfare Laboratory (USALWL) has undertaken this task to provide an intermediate or quick-fix solution to the problem.

### 7.3 BACKGROUND

As discussed with personnel in the field and engineers from Boeing Aircraft Vertol Division, emergency repairs encompass two categories; namely, the aircraft engines, aft exterior, and the generator and hydraulic system located inside the rear ramp area. Based on these facts, USALWL has developed two different types of shelters which can be used to protect mechanics from the elements during emergency repairs of the CH-47. These shelters will be referred to as, "the ramp enclosure", Figure 7.1, and the "the engine enclosure", Figure 7.2.





Figure 7.1. Ramp Enclosure



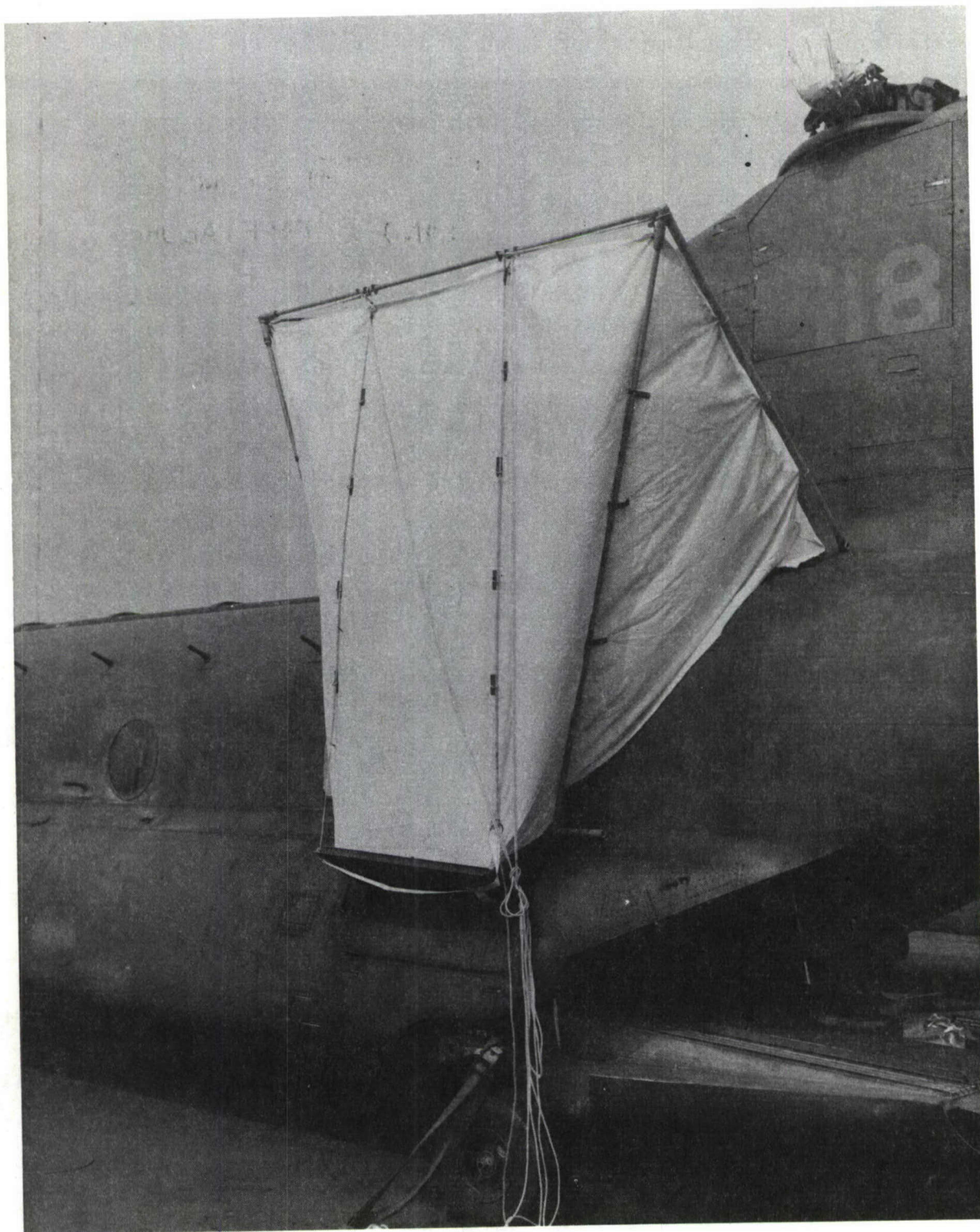


Figure 7.2. Engine Enclosure



## 7.4 DESCRIPTION OF MATERIEL

1. The ramp enclosure consists of a neoprene coated fabric which has been cut and fitted around the CH-47 rear ramp entrance. For ease of installation, two handles are provided so that one man can hold the fabric in position while the other man secures the fabric to the helicopter. Securing of the enclosure is accomplished by using guy lines and bungee cord to points on the helicopter. The loading ramp can be raised to a level position while the enclosure is in place.

2. The engine enclosure consists of a fiberglass frame covered with a neoprene coated nylon fabric, Figure 7.2. The fiberglass poles which are color coded, are assembled on the ground, Figure 7.3, and positioned around the engine as shown in Figure 7.4. The fiberglass frame is hoisted into position by the use of a guy rope which is attached around the opposite engine pod. Once the frame is positioned, the fabric enclosure is hoisted into position similar to a sail. Guy ropes are provided to anchor the fabric to the helicopter. A heat inlet is provided for use with the Herman Nelson Heater. This structure can be used on either side of the CH-47.

## 7.5 INSTRUCTIONS FOR ATTACHING AND REMOVING THE STRUCTURE

See Appendix A.

## 7.6 PURPOSE OF THE PROPOSED EVALUATION

The purpose of this evaluation is:

- a. To determine if the shelters provide adequate protection for individuals performing emergency repairs on CH-47 Helicopters.
- b. To identify any existing shortcomings and thereby determine if the shelters are suitable for production in operational quantities.
- c. To determine if any other repair shelters for other CH-47 helicopter locations are required and should be developed.
- d. To determine, if possible, if the Approved Materiel Need, reference 3, should be cancelled.



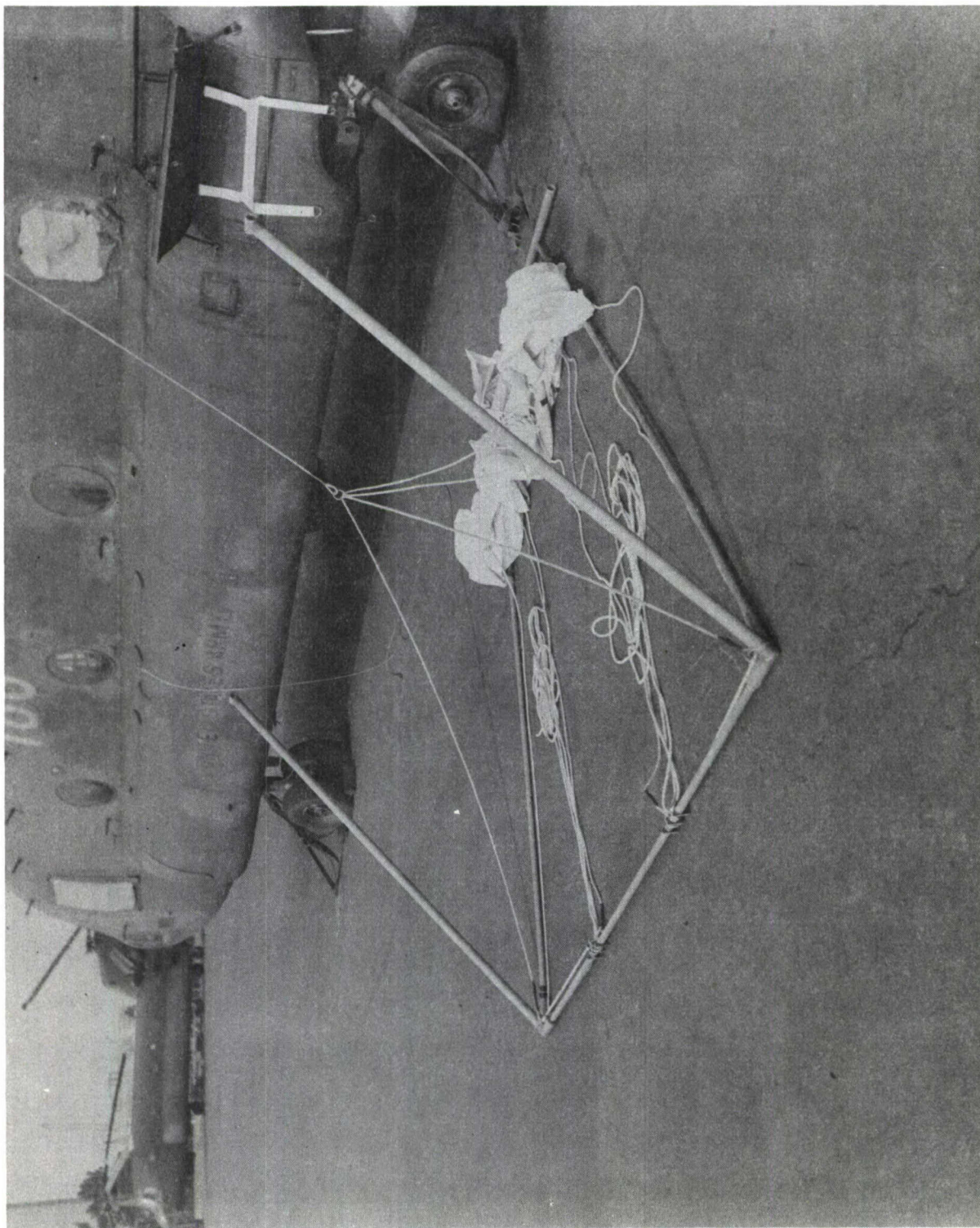


Figure 7.3. Engine Shelter Frame, Assembled



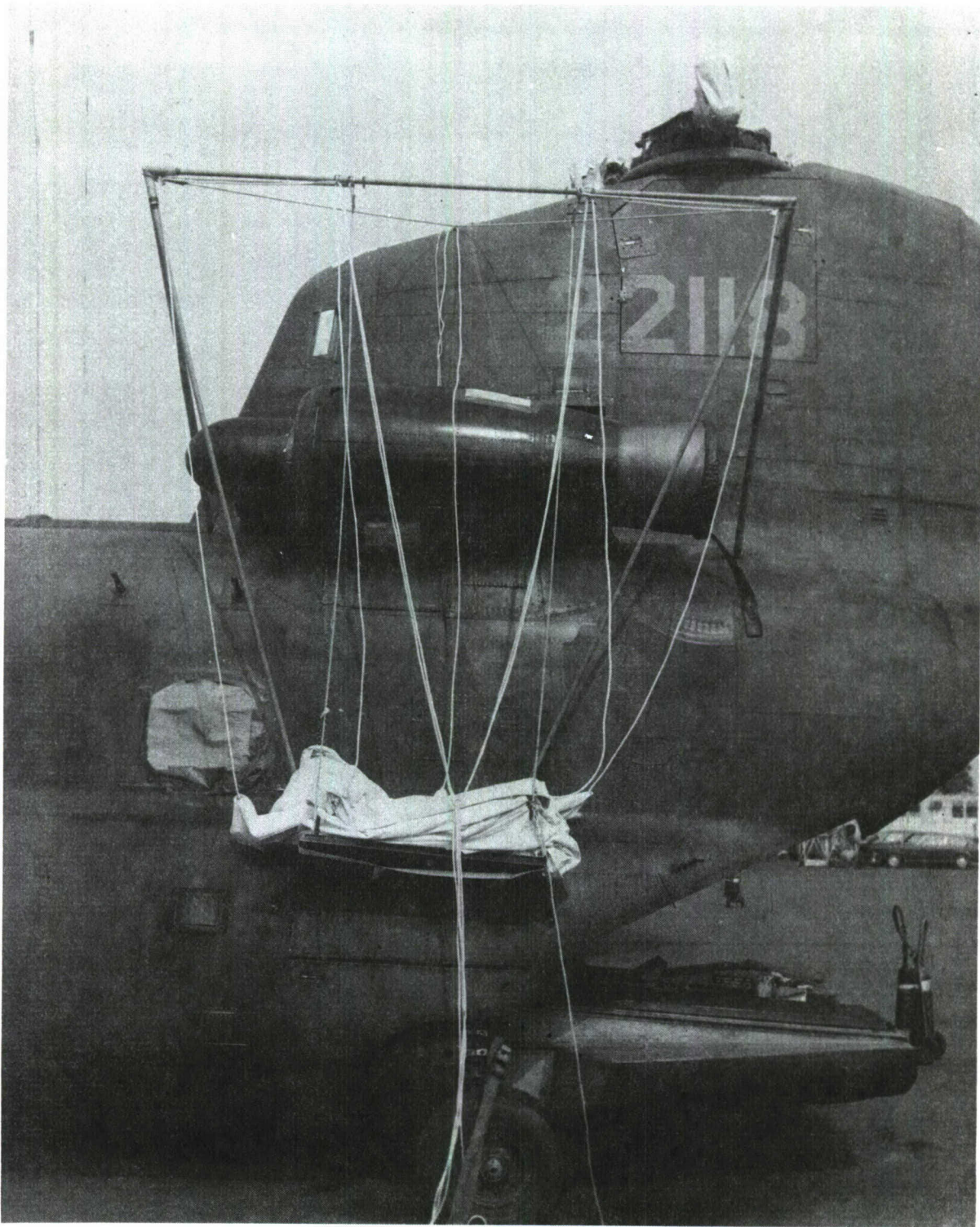


Figure 7.4. Engine Shelter Frame, Erected



## 7.7 TIME SCHEDULE

<u>Item</u>	<u>Time</u>
Training	3 Hours
Operation	3 Months
Questionnaire Response	30 Days
Report Preparation	60 days

## 7.8 PROCEDURE

Aviation units having CH-47 Helicopters will evaluate the shelters during simulated and actual emergency repairs under cold, wind conditions while wearing arctic clothing. The following procedures and comparisons, as applicable, should be followed in evaluating this item:

- a. Inspect the shipping container and contents to determine if the shelters have been damaged during shipment.
- b. Prior to the evaluation the shelters should be erected on the aircraft following the instructions outlined in paragraph 5 of the Proposed Evaluation Plan.
- c. During the field evaluation the engine enclosure should be evaluated without an external heat source as well as with the Herman Nelson Heater.
- d. The working space within the enclosures should be assessed for size suitability.
- e. The enclosures should be evaluated for ease of erection, durability and protection provided during severe weather conditions.

## 7.9 TRAINING

The test personnel should be instructed in and should practice the installation of the structure.

## 7.10 SUPPORT REQUIREMENTS

- a. CH-47 Helicopter
- b. Maintenance Personnel
- c. Herman Nelson Heater



## 7.11 SAFETY

A Safety Statement is not required.

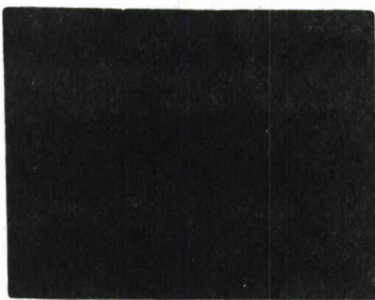
## 7.12 REPORTING PROCEDURE

The completed Questionnaires and a Letter Report of the evaluation prepared by the responsible officer should be forwarded to the Commander, U.S. Army Land Warfare Laboratory, Aberdeen Proving Ground, Maryland 21005.

## 7.13 DISPOSITION OF THE ITEMS

The CH-47 maintenance shelters may be retained by the evaluation units after completion of the evaluation.





F-C3305

## Appendix

A

INSTRUCTIONS FOR ATTACHING AND REMOVING THE STRUCTURE FOR  
THE EMERGENCY REPAIR SHELTER FOR THE CH47 HELICOPTERS



**THE FRANKLIN INSTITUTE RESEARCH LABORATORIES**  
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## APPENDIX A

### INSTRUCTIONS FOR ATTACHING AND REMOVING THE STRUCTURE FOR THE EMERGENCY REPAIR SHELTER FOR THE CH47 HELICOPTER

#### CARGO RAMP COVER INSTALLATION PROCEDURE

1. Lower cargo ramp to desired level for maintenance and retract apron fully.
2. Open packed cover enough to locate the ends of the ridge line with attached bungee cord.
3. Attach one end of "S" hook on bungee cord to the foot well located second from bottom of aircraft.
4. At this point, one man should hold the ramp cover above the trailing edge of the aircraft using lifting handles provided while the other man attaches the opposite end of the ridge line to the footwell on the opposite side of the aircraft.
5. Hook ends of belt lines located above ridge line into the handholds just above the lower work platforms.
6. Web ties should now be released dropping lower half of cargo cover.
7. Pull bungee drawstrings located on bottom of cover and attach one to hub of each rear wheel by simply taking one wrap of bungee around hub and attaching "S" hook to bungee.
8. Pull transverse tie line under ramp and secure to "D" ring on the tie line on opposite side of aircraft.
9. Inside aircraft secure floor tie lines to rear cargo tie downs in cabin floor.
10. Secure bungee cords to any convenient lightening holes within aircraft.

#### STRIKING CARGO RAMP ENCLOSURE

1. Unfasten bungee cords and tie lines within aircraft.
2. Disconnect transverse line from under aircraft ramp.
3. Disconnect bungee drawstrings from rear wheels.
4. For ease of future erections, fabric should be rolled and tied at mid-section using fabric tie tapes.
5. One man should hold lifting handles while other man disconnects belt tie lines and ridge lines.
6. Cover should be dropped to ground and repackaged.



## ENGINE SHELTER ERECTION PROCEDURE

1. Lay out components on ground next to aircraft as shown in Figure 4.1. (All parts are identified.) (Page 4-2)
2. Slide support arms on base bar. The longer arm, marked "forward", must be located on the base bar toward the end that is closest to the front of the aircraft.
3. Insert each strut through the three orange loops on the canopy. The loops are marked "L & R" for left and right and are numbered. The "T" bar end of the strut should be passed through the loops starting at Number 1.
4. The snap on the shroud lines of the canopy should be attached to the steel rings located on cross bar.
5. Insert the cone end of each strut in the strut socket on the upper end of the spar.
6. Insert the cross bar into the cross bar socket of one spar. When the strut and cross bar are fully inserted into their respective sockets, the cross bar locks the strut in place. Test the locking action by pulling straight out on the strut. If strut has not locked, withdraw cross bar about one inch and reinsert cross bar.
7. After both struts, spars and cross bar have been assembled, lock cross bar in place by attaching cross bar safety cords on steel ring along cross bar.
8. Insert the bottom end of one of the struts into the keyed hole in base bar. Rotate strut one quarter turn to lock in place. Insert other strut in same manner.
9. With the lower work platform opened and locked in place, lift the frame and set the base bar on the aircraft at the belt line and the top of the frame on the ground. The canopy should be laid on the work platform.
10. Position the open ends of the support arms on the inner edge of the work platform. Loop the base bar safety cords around the base bar (twice) and attach spring hooks to holes in metal tabs at rear edge of platform.
11. At this point one man can continue with the assembly on the ground while the other climbs up on the aircraft to install pylon harness and distal guy line.
12. Man on the ground should continue threading canopy ropes through cross bar. The ropes on each end of the canopy are passed through the pulley located at the top of the spar and then threaded through the steel ring along side of shroud lines. The two center canopy lines or remaining lines are also threaded through same steel rings beside shroud lines.



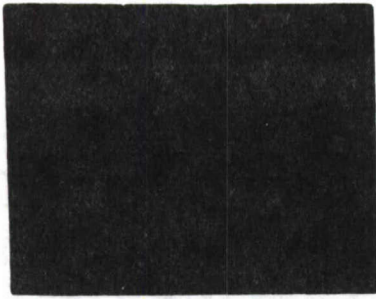
13. On top of the aircraft, the upper ends of the "Y" shaped pylon harness should be clipped into the upper most pylon hand holds. The harness should be run along the center ridge and leading edge of the pylon and the shock cord clipped into the slot at the leading edge of the base of the pylon. At this point, the rope which ties around the opposite engine should be on that side of the aircraft with the large "D" ring positioned on the side of the structure.
14. Loop the distal line around the engine nacelle on the far side and tie it at the far side "D" ring so that the distance from the center of the pylon to the "D" ring is approximately 18".
15. The man on the ground should throw the proximal guy line up to the man on top of the aircraft. The line is then threaded through the "D" ring and the slack taken up.
16. With the man on the ground lifting up the cross bar and the man on top hauling on the guy line, commence raising the frame. When the cross bar reaches the limit of the reach of the man on the ground, he should move to a position where he can continue to guide the framework by holding onto one of the struts. Guide the bearing ends of the spars past the ends of the engine till they come to rest on top of the aircraft along the line at the base of the drive shaft tunnel cover. The forward spar should be in front of the turbine shaft fairing. Tie the guy line securely and check the security of the distal section again.
17. The bungee cord on the shroud lines is then stretched and attached to the wheel area.
18. Group the canopy lines together and raise the enclosure up to the cross bar. Watch to see that the loops on the struts and the "D" rings on the shroud lines do not become fouled. When the enclosure has been raised evenly to all points, secure the canopy lines to the landing gear shackle.
19. Thread the line from the apex of the top panel through the small "D" ring on the pylon harness just aft of the guy line, and tie it securely.
20. Attach the canopy hooks to the spars and to the proximal guy line to support the top of the enclosure.
21. The enclosure can be tied through the center of the bearing ends of the spars.
22. Pull the drawstring under the work platform and hook together.
23. Grommets and ties are also provided so that the canopy material can be pulled under the base bar and tied into the belt line. A slit and tie arrangement is provided to fit the enclosure around the high voltage antenna.
24. Additional bungee cords can be attached as required.



### STRIKING THE SHELTER

1. Untie the enclosure where the high voltage antennae passes through.
2. Remove the heater connection if it was used.
3. Close the work platform zippers.
4. Untie and free the canopy material at the base bar.
5. Disconnect the bottom of the enclosure.
6. Untie the enclosure at the base of the spars.
7. Disconnect the hooks from the proximal guy lines and from the spars.
8. Untie the top panel and remove bungee hooks at the apex line and drop the top so that all of the panels are hanging vertically.
9. Untie the canopy lines and lower the enclosure to the work platform.
10. Disconnect the shroud lines.
11. Untie the proximal guy line from the distal guy line at the "D" ring and lower the frame away from the aircraft with one man on the ground to guide it.
12. Drop the proximal guy line to the ground.
13. Untie the distal guy line from the far side engine nacelle and remove the pylon harness.
14. Disconnect the base bar safety cords.
15. Lift the frame off of the aircraft and place it on the ground.
16. Rotate each strut one quarter turn and remove the base bar.
17. Remove the support arms from the base bar.
18. Pull the canopy lines out of the rings and pulleys.
19. Disconnect the cross bar safety cords, and pull the cross bar out of the spar sockets.
20. Pull the struts out of the spar sockets.
21. Pull the struts out of the canopy loops.





F-C3305

## Appendix

B

QUESTIONNAIRE FOR THE EMERGENCY REPAIR  
SHELTER FOR THE CH47 HELICOPTER



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APPENDIX B

QUESTIONNAIRE FOR THE  
EMERGENCY REPAIR SHELTER FOR THE CH47 HELICOPTER

1. Are the instructions for pitching and striking the enclosures, printed on the inside of the structures, clear and adequate? Yes \_\_\_\_  
No \_\_\_\_ If no, explain: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
2. Was the engine enclosure easy to erect? Yes \_\_\_\_ No \_\_\_\_ If no, explain: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
3. Was the ramp enclosure easy to erect? Yes \_\_\_\_ No \_\_\_\_ If no, explain: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
4. Does the engine enclosure provide sufficient protection without the use of the external heat source? Yes \_\_\_\_ No \_\_\_\_
5. Does the engine enclosure provide sufficient protection with the Herman Nelson Heater attached? Yes \_\_\_\_ No \_\_\_\_
6. Does the ramp enclosure provide sufficient protection? Yes \_\_\_\_  
No \_\_\_\_
7. Are the structures easy to remove and package? Yes \_\_\_\_ No \_\_\_\_  
If no, explain: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
8. Is there sufficient room within the structures to perform emergency repairs? Yes \_\_\_\_ No \_\_\_\_
9. Are there any other locations on the CH47 which require an emergency repair shelter? Yes \_\_\_\_ No \_\_\_\_ If yes, explain the location and identify the emergency repair needed: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_



10. In your opinion, do these and/or the additional shelters you have named in paragraph 9 fulfill the requirements for emergency repairs in the field on a CH47? Yes \_\_\_\_ No \_\_\_\_

11. Additional comments, remarks or recommendations concerning the CH47 protection enclosures: \_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
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7 December 1972

MEMORANDUM THRU: TECHNICAL DIRECTOR

FOR: COMMANDING OFFICER

SUBJECT: LWL Safety Committee Meeting, Session 75

1. The LWL Safety Committee, Session 75, met on 7 Dec 72 and consisted of the following members:

LTC R. A. Bronson, MOD	<u>R. A. Bronson</u>	(Concur)
Mr. L. S. D'Elcio, App Chem Br	<u>L. S. D'Elcio</u>	
Mr. J. I. Randall, Mat Read Br	<u>J. I. Randall</u>	
Mr. N. C. Wogsland, Munitions Br	<u>N. C. Wogsland</u>	
Mr. D. C. Adams, Safety Ofcr	<u>D. C. Adams</u>	
Mr. P. B. Ferrara, Chairman	<u>P. B. Ferrara</u>	

2. Item Discussed:

Emergency Repair Shelter for the CH47 Helicopter, LWL Task 08-S-71.

3. Description:

The repair shelter consists of a ramp enclosure and an engine enclosure. The ramp enclosure is a neoprene coated fabric which has been cut and fitted around the CH47 rear ramp entrance. Two handles are provided so that one man can hold the fabric in position while another secures it to the helicopter. Securing of the enclosure is by using guy lines and bungee cord to points on the helicopter. The loading ramp can be raised to a level position while the enclosure is in place. The engine enclosure is a Fiberglas frame covered with a neoprene coated nylon fabric. The Fiberglas poles which are color coded are assembled on the ground and then positioned around the engine. Guy ropes are provided to anchor the fabric to the helicopter. A heat inlet is provided for use with the Herman Nelson heater.

4. Discussion:

Mr. N. Leibel, Task Officer, presented the item and explained its use. Questions arose as to whether the enclosures would burn in case of a fire and if carbon monoxide would be a problem when using the Herman Nelson heater. Mr. Leibel said the fabric would not support fire and that fit of the enclosure to the aircraft should allow for sufficient ventilation when working.



5. The Committee recommended that:

a. Potential users of the repair shelter be notified in the Evaluation Plan or Instruction Manual that adequate ventilation in the shelter be maintained when using Herman Nelson or other similar heaters.

b. A Safety Statement is not required.

6. Acknowledgment:



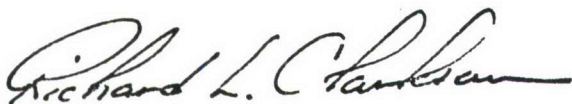
NORMAN P. LEIBEL  
Task Officer

7. Recommend approval.



PETER B. FERRARA  
Chairman

APPROVED:



RICHARD L. CLARKSON  
Colonel, GS  
Commanding

8 DEC 1972



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13. ABSTRACT <p>The purpose of this task was to design, develop and fabricate two sets of emergency repair shelters to fit the CH47 helicopter.</p> <p>Each set was to consist of two individually separate units. The one is essentially a curtain like flap to enclose the rear cargo ramp opening. The other covers either the port or starboard engine and is comprised of a fiberglass framework and tent like shelter. In general, the shelters were required to be lightweight and easily erected and disassembled. They were to be constructed to withstand wind velocities up to 40 miles per hour.</p> <p>This report provides a discussion of the design considerations, a comprehensive description of the final shelter assemblies and instructions for their use.</p>			

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